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ART. I.—*On the construction of a Normal Map of the Solar Spectrum.* An abstract of a memoir read before the National Academy of Sciences, Aug. 7th, 1866; by WOLCOTT GIBBS, M.D., Rumford Professor in Harvard University.

THE extraordinary impulse which has been given to the study of the spectrum by the investigations of Bunsen and Kirchhoff has led to an accumulation of details which have not yet been systematically or even conveniently arranged. To a certain extent at least this has arisen from the want of a standard map of the solar spectrum upon which new lines may be entered with precision as regards their relative places. The well known chart of Kirchhoff, though executed with great care and labor, is not, properly speaking, normal, since it only represents a spectrum formed by four flint glass prisms, the angles of which, it is true, are given, but of which the indices of refraction are not stated. Moreover the prisms were not placed accurately in the positions of least deviation for each of the spectral lines. The scale of millimeters adopted by Kirchhoff is therefore a purely arbitrary one.

A standard or normal map of the spectrum must be wholly independent of peculiarities in the form of apparatus, in the number of prisms, their refractive and dispersive powers and their positions. Such a map can only be based upon the wave lengths of the spectral lines, since these do not, like the indices of refraction, vary with the material of which the prisms are composed.

The diffraction spectrum as obtained by a glass plate ruled with from one to ten thousand lines to the inch gives a nearer approach to a perfectly normal spectrum than any which has hitherto been proposed, and has been employed by Fraunhofer,* Mossotti† and Draper.‡ But even in this case there is a position of least deviation for each line depending upon the angle which the incident beam of light makes with a normal to the plane of the ruled surface, and in addition, it is necessary either to fix upon a standard number of lines to be ruled upon each millimeter of glass surface, or to reduce the positions of the spectral lines to those which would have been obtained with a standard ruled surface.

We avoid all these difficulties by constructing a normal spectrum in such a manner that each spectral line shall be entered according to its wave length, a method first suggested, I believe, by Billet.§

The materials which the present condition of science furnishes for the construction of a chart of the spectrum upon the principle laid down are not very copious. They consist essentially of the older measurements of Fraunhofer‖ of the wave lengths of the lines B, C, D, E, b, F, G and H; of recent and very accurate measurements by Angström;¶ of a still more extended series by Ditscheiner;** of the measurements of Plücker†† for certain lines in the spectra of gaseous media, and of those of Esselbach‡‡ for the ultra-violet rays. In addition we have a small number of isolated measurements by Müller,§§ Mascart,‖‖ Stefan,¶¶ and Ketteler.***

For the construction of the chart which I present herewith to the Academy I have selected the wave lengths determined by Angström as standards. This has been done because both the ruled glass and the measuring apparatus employed by him appear to have been much more perfect than those of other observers—Fraunhofer not excepted. On the other hand, however, all of Angström's measures are not available for the reason that the identification of the lines as produced by particular elements does not appear to be in all cases absolutely certain. As Angström's measurements are in ten-millionths of a Paris inch they have been reduced to millionths of a millimeter by multiplying them by the constant 27·07.

Ditscheiner's measurements agree closely with those of Ang-

* Denkschr. Münch. Acad., Bd. viii, 1821–22.
† Annali delle Univer. Toscane, t. i, 1845; also Pogg. Ann., lxii, p. 509.
‡ L. & E. Phil. Mag., xxvi, 1845.
‖ Loc. cit.
§ Traite d'Optique, vol. i, p. 47.
¶ Pogg. Ann., cxxiii, p. 489.
** Sitzungsberichte der k. k. Akad. der Wiss., Bd l, 1864.
†† Pogg. Ann., cvii, p. 497.
‡‡ Pogg. Ann., xcviii, p. 513.
§§ Pogg. Ann., cxviii, p. 641 and cxxix, p. 637.
‖‖ Pogg. Ann., cxviii, 367.
¶¶ Pogg. Ann., cxxii, p. 684.
*** Pogg. Ann., cxxiv, p. 390.

ström after undergoing a correction which depends upon the value of the wave length of the more refrangible line of D. This value is taken by Ditscheiner as 588·8, the wave length as determined by Fraunhofer. But as, for the reasons above mentioned I consider the results of Angström more reliable, I have taken his value, 589·43, in place of that of Fraunhofer, and have reduced all the measurements of Ditscheiner in accordance with this assumption. The following table will suffice to show the agreement between the two series of measurements.

TABLE I.

Angström.	Ditscheiner.	Diff.	Angström.	Ditscheiner.	Diff.
687·49	687·81	+0·32	527·32	527·42	+0·10
656·76	656·66	−0·11	523·69	523·74	+0·05
619·17	619·72	+0·55	519·63	519·67	+0·04
617·08	617·50	+0·42	518·79	518·73	+0·06
616·33	616·73	+0·40	517·66	517·70	+0·04
614·31	614·24	−0·07	517·15	517·15	0·00
612·34	612·76	+0·42	492·23	492·22	−0·01
610·45	610·82	+0·36	491·41	491·41	0·00
590·04	590·07	+0·03	489·50	489·54	+0·04
589·43	589·43		487·55	487·55	0·00
561·99	561·98	+0·01	486·52	486·49	−0·03
560·70	560·77	+0·07	440·81	440·87	+0·06
559·10	559·13	+0·03	438·63	438·75	+0·12
557·66	557·77	+0·11	434·28	434·34	+0·06
545·97	546 05	+0·08	432·78	432·82	+0·04
545·07	545·08	+0·01	431·03	431·35	+0·32
534·41	534·41	0·00	397·16	397·10	−0·06
533·16	533·29	+0·13	393·59	393·74	+0·15
528·73	528·79	+0 06			

A number of Ditscheiner's measurements refer to lines which cannot certainly be identified with the lines produced by particular elements. These lie between G and H and have been omitted as useless for our present purpose. But in the greater number of cases the wave lengths in his table of results are referred directly to the lines given in Kirchhoff's chart, which not merely enables us to identify them, but permits us to obtain the wave lengths of the intermediate lines by interpolation. The following table gives the corrected values of all the wave lengths measured by Ditscheiner with the exception of those between G and H, and of those of the nine principal lines of Fraunhofer which are given in Table I.* For these I have taken the values given by Angström. I have not ventured to make a further use of Angström's determinations for the reason that it is only through a comparison with the measurements of Ditscheiner that they can be identified with the lines upon Kirchhoff's scale. In every part of the spectrum excepting that between C and D the agreement between the two sets of measurements appears to fall within the limits of the errors of observation.

* Marked in Table II with asterisks.

TABLE II.

Kirchhoff's Line.	Wave Length.	Kirchhoff's Line.	Wave Length.	Kirchhoff's Line.	Wave Length.	Kirchhoff's Line.	Wave Length.
A 404·5	*761·20	1242·6	557·77	1737·7	511·42	2221·7	474·34
B 592·7	*687·49	1280·0	553 27	1750·4	510·30	2233·7	473·36
C 694·1	*656·77	1303·5	551 13	1777·5	508·41	2250·0	472·26
711·4	652·09	1306·7	550·70	1799·0	506·91	2264·3	470·21
719·6	650·05	1324·8	548·13	1834·3	504·55	2309·0	467·07
783·8	634·05	1337·0	546·78	1854·9	503·25	2416·0	460 63
831·0	623 61	1343·5	546·05	1867·1	502·26	2436·5	458·66
849·7	619·72	1351·1	545·08	1873·4	501·67	2457 5	456·81
860·2	617 50	1367·0	543·42	1885·8	501·07	2467 6	455·71
863·9	616·73	1389·4	540 91	1908·5	499·72	2489·4	453·73
874·3	614·74	1410·5	538·79	1920·2	498·78	2537·1	450·56
877·0	614·24	1421·5	537·52	1960·8	496·15	2547·2	450·13
884·9	612·76	1449·4	534·41	1975·7	495·04	2566·3	448·46
894·9	610·82	1463·3	533·29	1983·3	494·34	2606·6	446·00
959·8	598·14	1492·4	530·22	1989·5	493·76	2627·0	444·65
Dβ 1002 8	*590·04	1506·3	528·79	2001·6	492·22	2638·5	443·85
Dγ 1005·0	589·74	1515·5	528·02	2018·5	491·41	2670·0	442·29
Dα 1006·8	*589·43	E 1523·7	*527·38	2041·3	489·54	2686 6	440·87
1029·3	586·26	1541·9	525·98	2058·0	488·18	2721·6	438·75
1096·1	576·72	1569 6	523·74	2067·1	487 55	2734·1	437·80
1102·9	575·78	1577 6	523·09	F 2080·0	*486·52	2775·7	435·67
1135·1	571·51	1589·1	521·97	2103·3	484·63	2796·7	434·34
1155·7	568·70	1601·7	521·32	2119·8	482·81	2822·3	432·82
1174·2	566 33	1622·3	519 67	2148·9	480·56	G 2854·7	*431·03
1200.6	562·97	1634·1	518 73	2157·4	479 55	2869·7	430·37
1207·3	561·98	b 1648·8	517·70	2160·6	479·23	H	*397·16
1217·8	560·77	1655 6	517·15	2187·1	476·93	H′	*393·59
1237·8	559·13	1693·8	514·65	2201·9	475·90		

Table II, embracing determinations of 111 wave lengths, has served as the basis for the construction of the interpolation curves which are herewith submitted to the Academy.

By means of these curves the values of the wave lengths for every tenth line of Kirchhoff's scale from line 694 or C, to line 2854·7 or G, have been determined. These values are given in the following table. Similar relations cannot at present be found for the lines between A and B, or between B and C, on account of the absence of the requisite measurements.

TABLE III.

Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.
700	655 05	2·70	800	630·30	2·20	900	609·72	2·27	1000	590·45	1·65
10	652·35	2·65	10	628·10	2·10	10	607·45	1·95	10	588·80	1·70
20	649·70	2·60	20	626·00	2·10	20	605·50	1·95	20	587·10	1·65
30	647·10	2·50	30	623·90	2·05	30	603·55	1·90	30	586·05	1·50
40	644·60	2·50	40	621·85	2·18	40	601·65	1·85	40	584·55	1·50
50	642·10	2·50	50	619 67	2·20	50	599·80	1·80	50	583·05	1·40
60	639·60	2·40	60	617·47	1·85	60	598·00	2·30	60	581 65	1·40
70	637·20	2·30	70	615·62	1·92	70	595 70	1·85	70	580·25	1·40
80	634·90	2·30	80	613·70	2·01	80	593·85	1·70	80	578·85	1·35
90	632·60	2·30	90	611·69	1·97	90	592·15	1·70	90	577·50	1·30

TABLE III—(continued.)

Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.
1100	576·20	1·45	60	524·25	0·85	10	492·05	0·80	70	455·65	0·85
10	574·75	1·40	70	523·45	0·80	20	491·25	0·75	80	454·80	0·85
20	573·35	1·35	80	522·70	0·75	30	490·50	0·90	90	454·05	0·75
30	572·00	1·35	90	521·95	0·75	40	489·60	0·80	2500	453·30	0·75
40	570·65	1·35	1600	521·20	0·75	50	488·80	0·80	10	452 55	0·75
50	569·30	1·25	10	520·50	0·70	60	488 05	0·75	20	451·80	0·70
60	568·05	1·25	20	519·75	0·75	70	487·30	0·84	30	451·10	0·70
70	566·80	1·30	30	519·05	0·70	80	486·46	0 86	40	450·40	0·65
80	565·50	1·30	40	518·35	0 70	90	485·60	0 75	50	449·75	0·70
90	564·20	1·30	50	517·65	0·70	2100	484·85	0·82	60	449·05	0·65
1200	562·90	1·25	60	516·90	0·75	10	484·03	1·26	70	448·40	0·70
10	561·65	1·20	70	516·15	0·75	20	482·77	1·17	80	447·70	0·65
20	560·45	1·20	80	515·45	0·70	30	481·60	0·60	90	447·05	0·65
30	559·25	1·20	90	514·75	0·70	40	481·00	0·74	2600	446·40	0·65
40	558·05	1·25	1700	514 00	0·75	50	480·26	0·97	10	445·75	0·65
50	556·80	1·20	10	513·30	0 70	60	479 29	1·29	20	445·10	0·65
60	555·60	1·10	20	512·60	0·70	70	478·00	1·13	30	444·45	0·70
70	554·50	1·20	30	511·85	0·75	80	476·87	0 61	40	443 75	0·70
80	553·30	1·05	40	511·15	0 70	90	476·26	0·34	50	443·05	0·60
90	552·25	1·10	50	510·45	0·70	2200	475·92	0 62	60	442·45	0·70
1300	551·15	0·79	60	509·65	0·80	10	475 32	0·82	70	441·75	0·60
10	550·36	1·54	70	508·95	0·70	20	474 50	0·80	80	441·15	0·60
20	548·82	1·35	80	508·25	0·70	30	473·70	0·90	90	440·55	0·60
30	547·47	1·06	90	507·55	0·70	40	472·80	0 80	2700	439·95	0·60
40	546·41	1·31	1800	506 80	0·75	50	472·00	0 85	10	439·35	0·60
50	545·10	1·10	10	506 15	0·65	60	471·15	0 85	20	438 80	0·55
60	544·00	0·83	20	505·50	0·65	70	470·30	0 80	30	438·25	0·55
70	543·17	0·93	30	504·80	0·70	80	469 50	0·80	40	437·70	0·55
80	542·24	1·44	40	504·10	0·70	90	468·70	0·75	50	437 10	0·60
90	540·80	0·70	50	503·45	0·65	2300	467·95	0·75	60	436·50	0 60
1400	540·10	1·15	60	502·75	0·70	10	467·20	0·75	70	435·90	0 60
10	538·83	1·06	70	502 05	0·70	20	466·45	0·65	80	435·30	0 60
20	537·77	1·34	80	501·40	0·65	30	465·80	0·65	90	434 75	0·55
30	536 43	1·20	90	500·80	0·50	40	465 15	0·65	2800	434·20	0·55
40	535·23	0·80	1900	500·20	0·60	50	464·50	0·65	10	433.60	0·60
50	534·43	0·83	10	499·55	0·65	60	463·85	0·60	20	433·00	0·60
60	533·60	0·94	20	498·90	0.65	70	463·25	0·60	30	432·45	0·55
70	532·66	1·16	30	498·25	0·65	80	462·65	0·60	40	431·90	0·55
80	531·50	1·00	40	497·55	0·75	90	462·05	0·55	50	431·30	0·60
90	530·50	0·95	50	496·80	0·70	2400	461·50	0·55	60	430·70	0 60
1500	529·55	0·95	60	496·10	0·70	10	460·95	0·95	70	430·10	0·60
10	528·60	0·95	70	495·40	0·70	20	460·00	0·90			
20	527·65	0·90	80	494·55	0·85	30	459·10	0·85			
30	526·75	0·90	90	493·75	0·80	40	458·25	0·90			
40	525·95	0·85	2000	492·95	0·80	50	457·35	0·85			
50	525·10				0·90	60	456·50				

To find the wave length of any line in Kirchhoff's table, or upon his chart, from Table III, it is only necessary to employ the simple formula $\lambda' = \lambda - \frac{1}{10}(\varkappa' - \varkappa)\,\Delta\lambda$

in which λ' represents the wave length sought and $\varkappa'$ the corresponding line upon Kirchhoff's scale; λ the wave length of the next lower line $\varkappa$ in Table III, and $\Delta\lambda$ the corresponding difference also given in the table. It is not necessary in any case to employ second differences. The following table will serve to

show the degree of accuracy attainable by means of the formula above given and the data in Table III.

TABLE IV.

Kirchhoff.	Calcul.	Found.	Diff.	Kirchhoff.	Calcul.	Found.	Diff.	Kirchhoff.	Calcul.	Found.	Diff.
711·4	651·96	652 09	−0·03	1421·5	537·57	537·52	+0·05	2067·1	487·52	487·55	−0·03
719·6	649·81	650·05	−0·24	1449·4	534·48	534·41	+0·07	2080·0	486·46	486·52	−0·06
783·8	634·03	634·05	+0·02	1463·4	533·29	533·29	0·00	2103·3	484·58	484·63	−0·05
831·0	623·69	623·61	+0·08	1492·4	530·28	530·22	+0·06	2119·8	482·80	482·81	−0·01
849·7	619·87	619·72	+0·15	1506·3	528·95	528·79	+0·16	2148·9	480·60	480·56	+0·04
860·2	617·44	617·50	−0·06	1515·5	528·08	528·02	+0·06	2157·4	479·55	479·55	0·00
863 9	616·75	616·73	+0·02	1523·7	527·30	527·38	−0·08	2160·6	479 23	479·23	0·00
874·3	614·80	614·74	+0·06	1541·9	525·80	525·98	−0·18	2187·1	476·44	476·93	−0·49
877·0	614·28	614·24	+0·04	1569·6	523·48	523·74	−0·26	2201·9	475·78	475·90	−0·12
884·9	612·72	612·76	−0·04	1577·6	522·88	523·09	−0·21	2221·7	474 37	474·34	+0·03
894·9	610·73	610·82	−0 09	1589·1	522·02	521·97	+0·05	2233·7	473·37	473·36	+0·01
859·8	598 40	598·14	+0·26	1601·7	521·07	521·32	−0·25	2250·0	472·00	472·26	+0·26
1002·8	589 99	590·04	−0·05	1622·3	519·58	519·67	−0·09	2264·3	470·79	470·71	+0·08
1004·8	589·66	589·74	−0·08	1634·1	518·76	518·73	+0·03	2309·0	467·27	467·07	+0·20
1006·8	589·33	589 43	−0·10	1648·8	517·73	517·70	+0·03	2416 0	460·62	460·63	−0·01
1029·3	586·17	586·26	−0·09	1655·6	517·26	517·15	+0·11	2436·5	459 51	458·66	+0·85
1096 1	576·78	572·72	+0·06	1693·7	514·49	514·65	−0·16	2457·5	456·71	456·81	−0·10
1102·9	575·82	575·78	+0·04	1737·7	511·27	511·42	−0·15	2467 6	455·85	455·71	+0·14
1135·1	571·31	571·51	−0·20	1750·4	510·42	510·30	+0·12	2489·4	453·35	453·73	−0·38
1155·7	568·53	568·70	−0·17	1777·5	508·42	508·41	+0·01	2537·1	450·60	450·56	+0·04
1174·2	566·27	566·33	−0·06	1799·0	506·87	506·91	−0·04	2547·2	449·93	450·13	−0·20
1200·6	562·82	562·97	−0·15	1834·3	504·50	504·55	−0·05	2566·3	448·64	448·46	+0·18
1207·0	561·99	561·98	+0·01	1854·9	503·11	503·25	−0·14	2606·6	445 97	446·00	−0·03
1217·8	560·67	560·77	−0·10	1867·1	502·25	502·26	−0·01	2627·0	444·64	444·66	−0·01
1237·8	558·31	559·13	−0·32	1873·4	501·85	501·67	+0·18	2638·5	443·85	443·85	0·00
1242·6	557·74	557·77	−0·03	1885·8	501·05	501·07	−0·02	2670·0	441·75	442·29	−0·54
1280·0	553·30	553·27	+0 03	1908·5	499·65	499·72	−0·07	2686 6	440·75	440·87	−0·12
1303·5	550·88	551·13	−0·25	1920·2	498·89	498·78	+0·11	2721 6	438·71	438·75	−0·04
1306·7	550·61	550·70	−0·09	1960·8	496·04	496·15	−0·11	2734·1	438·02	437·80	+0·22
1324·8	548·18	548·13	+0·05	1975·7	495·00	495·04	−0·04	2775·7	435·56	435·67	−0·11
1337·0	546·73	546·78	−0·05	1983·3	494·48	494·34	+0·14	2796·7	434·38	434·34	+0·04
1343·5	545·96	546·05	−0·09	1989·5	493·71	493·75	−0·04	2822·3	432 86	432·82	+0·04
1351·1	544·98	545·08	−0·10	2001·6	492·81	492·22	+0·59	2854 7	431·60	431·03	+0·57
1367·0	543·42	543·42	0·00	2018·5	491·37	491·41	−0·04	2869·7	430·08	430·37	−0·21
1389·4	540·89	540·91	−0·02	2041·3	489·50	489·54	−0·04				
1410·5	538·78	538·79	−0·01	2058·0	488·16	488·18	−0·02				

From the above table it will be seen that wave lengths may usually be determined correctly in the first decimal place when the corresponding line upon Kirchhoff's scale is known to the tenth of one millimeter. From Table I it will be seen that wave lengths as determined by two observers differ almost always by several units in the second decimal, and not rarely even in the first, so that Table III will give results within the probable errors of observation. It must however be remarked that the data for the calculation of Table III have not been equally numerous for equal intervals of Kirchhoff's scale, and the table is not therefore *equally* reliable in all its parts. New measurements of wave lengths are needed to give greater precision, especially between the numbers 890—1000 and 1030—1090.

Kirchhoff's measurements have not hitherto been extended beyond the line G. For this portion of the spectrum we pos-

sess the beautiful photographic charts of Mr. Rutherfurd extending from b to H′. These charts are not however at present available for the determination of wave lengths, because the lines upon them beyond G have not yet been identified with lines whose wave lengths have been measured.

The very numerous measurements of Mr. Huggins* give the relative positions of a great number of spectral lines characteristic of particular elements. To give these measurements a real value the corresponding wave lengths must be determined as in the case of Kirchhoff's lines. I am not at present able to state to what extent this has been done, or whether it will be possible without a great number of new measurements of wave lengths to reduce the scale-numbers given by Mr. Huggins to the wave standard. If this can be done, we shall be able to fill up the portion of the spectrum beyond the line G not examined by Kirchhoff, and for which Ditscheiner's measurements are not available.†

In any event the tables and formula above given will enable an observer to determine the wave length of any new spectral line by simple comparison with Kirchhoff's chart, provided only that the line lies between B and G. In practice I suggest that this comparison may be readily made directly. Let for example three or four flint glass prisms be used with the spectroscope so as to give an amount of dispersion approximately equal to that of Kirchhoff's apparatus. If now a scale telescope be employed with an object glass of about 18 inches focal length, it will be easy to place Kirchhoff's chart in such a position that the reflected image of any small portion of it shall be in the field of view of the observing telescope at the same time with the direct image of the part of the solar spectrum containing the line the wave length of which is to be determined, which line may then also be brought into the field of view by means of a small prism covering a part of the slit of the collimator in the usual manner. If the scale telescope be provided with a rectangular prism placed at a convenient distance from the object glass and so that the hypothenuse of the prism shall make an angle of 45° with the vertical, the chart may be laid flat upon the table and moved into any convenient position. Finally, the magnitude of the reflected image of the scale may be reduced at pleasure by interposing a concave lens and suitably varying the distance of the scale. When the position of the given line with reference to any two adjacent lines, or to any scale number upon Kirchhoff's

* Philosophical Transactions for 1864; also Pogg. Ann., cxxiv, p. 275.

† Since the above was written I have succeeded, by comparing the lines upon Mr. Huggins' scale with those upon Kirchhoff's scale, in constructing interpolation tables for the former similar to Table III. These I shall hereafter publish in extenso together with the wave lengths of all the elements given by both observers. —W. G. Nov. 1st, 1866.

chart, has been determined, the wave length may be found from Table III.

The determination of wave lengths by the method of comparison which I have explained above, is analogous to the determination of the place of a star by comparison with that of another star whose place is known. It is easy to see that when the wave lengths of a sufficient number of lines have been determined with accuracy for the purposes of comparison, the wave length of a given line may be found with very nearly as much precision as by direct measurement with a ruled glass. For in a large spectroscope with five or six prisms of high dispersive power, the angular separation of two lines differing in wave length by only a single millionth of a millimeter, is so great that the interval may be readily divided into hundredths. Of course the magnitude of this interval for the same system of prisms will differ in different parts of the spectrum, being greatest for the most refrangible rays. But the interval will always be sufficient to give us the advantage of determining a small difference in magnitude by the measure of a considerable distance in space. To the best of my knowledge this method of determining wave lengths is new.

The spectroscope enables us however to determine wave lengths by another method which, though not new in principle, has not received the attention which it deserves, and has been applied in practice only in certain cases. I refer to the employment of the interference bands of Talbot, an application first made by Esselbach* in the measurement of the wave lengths of the ultra-violet rays. The method in question exhibits an extraordinary degree of precision when a spectroscope with several prisms of high dispersive power is employed, since in this case interference plates of considerable thickness may be used so as to produce very numerous dark bands. By measuring the number of bands between the given spectral line and two other spectral lines whose wave lengths are known, the wave length of the line in question may at once be found.† This method possesses the further advantage, that by employing several interference plates of different thicknesses or different kinds of glass, a number of independent measurements may be made, the mean of which may be taken. A number of observations may also be made with a single plate and different pairs of comparison lines.

The chart which is herewith presented to the Academy must be regarded simply as a first approximation to a normal chart of the spectrum. It contains 187 lines, the wave lengths of which have been accurately determined. The chart is drawn to a scale of millimeters, and in entering the lines of the spectrum upon

* Pogg. Ann., xcviii, 513.

† See Müller's Lehrbuch der Physik und Meteorologie, Bd. i, p. 850.

it each millimeter of the chart corresponds to the one-millionth of a millimeter of wave length. The probable error of measurement in determining the wave length does not usually exceed one or two ten-millionths of a millimeter, and the spectral lines have been ruled by a dividing engine upon the copper plate of the engraver so as to be correct in position to about one-tenth of a millimeter upon the chart. The substance generating each line is indicated by a dotted line and symbol as in Kirchhoff's chart, while the seven principal lines of Fraunhofer are denoted by the usual letters. In order to permit a comparison of the lines characteristic of different elements closely related to each other in their chemical properties, or belonging to the same natural groups, several impressions of the scale have also been printed upon a single sheet parallel to each other. Upon these the lines may be entered by hand. Copies of the scale have also been printed at the bottoms of large sheets so as to permit of the construction of dispersion curves. The comparison of the wave lengths of the spectral lines which characterize elements belonging to the same natural family may hereafter lead to interesting results, but at the present time it is difficult to institute such a comparison for the reason that we do not know all the lines which are produced by any one element. For the same reason it would probably be impossible at present to determine whether there is any law governing the wave lengths of the spectral lines belonging to the elements as regards their intervals or distribution over the spectrum. The conviction that precise knowledge of these and similar points must depend upon a knowledge of wave lengths and not merely of indices of refraction, has led me to make this first attempt to form a normal map of the spectrum. As a first attempt merely it is necessarily imperfect, but my object will be fully attained if I shall have succeeded in pointing out the path to be followed in the future discussion of the subject.

My grateful acknowledgments are due to Prof. J. E. Hilgard, under whose superintendence most of the curves which I have employed for interpolation have been drawn in the office of the Coast Survey. To Mr. S. P. Sharples I am also indebted for much assistance in the work of computation.

Cambridge, July, 1866.

Postscript.—Since the above was written I have received a second paper by Ditscheiner* on the wave lengths of the spectral lines, in which the author gives the results of a determination of the absolute value of the interval between two successive lines of the grating or ruled glass surface employed by him. When this value is used the wave lengths of Dβ and Dα become

* Sitzungsberichte der kaiserlichen Akad. der Wissenschaften, Band lii, 289.

respectively, as measured by Ditscheiner, 590·53 and 589·89, which are 0·49 and 0·46 higher than those of Angström as given in Table I. Ditscheiner in this second paper has recomputed the table given in his first memoir. The results are much higher than those of Angström or those given in my reduction of Ditscheiner's first measurements, the average difference being about 0·4 of one unit. The close agreement of the two sets of results given in Table I appears to me a sufficient reason for adhering to the values of the wave lengths employed in this paper as data for interpolation.

Cambridge, August, 1866.

Art. II.—*John Francis Encke.**

John Francis Encke, born Sept. 23, 1791, was the youngest son but one of the deacon of the Jacobi Church in Hamburg. Four years after his birth his father died, leaving the care and the education of eight children to his mother, a lady of much worth, and happily possessed of great mental energy.

The first tutor of the boy was Mr. Hipp, a gentleman possessing considerable aptitude for mathematical teaching; and to his honor be it spoken, a man who rendered valuable pecuniary assistance to the orphan and moneyless family. Hipp continued this material encouragement to young Encke even after the time that he entered the College at Hamburg, well known as the Johaneum. At this College, then under the directorship of Gurlitt, who enjoyed a high reputation for classical learning, the boy-student rapidly advanced, and in addition to considerable ability in Latin composition, his knowledge of Greek was sufficient to enable him to translate and enjoy the Lyricks of Pindar. Notwithstanding, however, this early classical training, when the time came for his entrance at the University, Encke resolved henceforth to devote his attention mainly, if not exclusively, to the study of astronomy.

But here came a very formidable impediment; there were ample funds at the disposal of a poor clergyman's son for a theological career, but none for the prosecution of so unusual a study. Nevertheless, such was the acknowledged ability, and so determined was the inclination, of young Encke, that, as is happily not unusual in such cases, all the difficulties yielded at length to perseverance, and to his great joy, in Oct. 1811, he found himself at Göttingen, and a student under the celebrated Gauss.

The very newspapers of Hamburg were at that day compulsorily printed in French; as a condescension, however, or as an insult to the inhabitants, a German translation was added; in a

* From the Monthly Notices of the Astronom. Soc. of London, 1866, p. 129.

like spirit even the university matricula of the old "Georgia Augusta" of Göttingen had the image and superscription of Jerome Buonaparte printed upon it. No wonder then that neither Gauss nor astronomy could retain the young student at his books, but, obeying the impulse which animated the whole heart of Germany, in the spring of 1813 he took up arms and marched to Hamburg for the rescue of his country from the domination of the French. After the re-occupation of Hamburg by the foreigner, Encke entered the Hanseatic Legion, then in process of formation in Holstein and Mecklenburg, and there he served as a sergeant-major in the horse artillery until July, 1814. In the autumn of this year he returned to Göttingen and to his astronomical pursuits, and for nearly twelve months continued a diligent student of subjects far more peaceable, and far more congenial to his turn of mind. Nevertheless the return of Napoleon from Elba once more finds him in a soldier's uniform, but now only for a short period, and, happily, for the last time. Waterloo and its consequences restored peace to France and to Europe, and young Encke, who in peace had no taste for soldiership and a uniform, returned, for the third time, to Göttingen and to Gauss. It was thus in the midst of these stirring and troublesome events, that the spirits of such men as Franz Encke and Wilhelm Struve were disciplined and matured.

While Encke was serving as a lieutenant of artillery in the Prussian fortress of Kolberg, he became acquainted with the celebrated Lindenau, at once astronomer and statesman, and after the completion of his studies under Gauss, he was appointed, by the influence of the former, an sssistant in the Observatory of Seeburg, not far from Gotha. In 1820 he became Vice-director, and in 1822 he was appointed Director, in the place of Lindenau, who returned to his political career.

It was at Seeberg that Encke commenced and completed his important work on the "Transits of Venus in 1761 and 1769," published at Gotha in 1822 and 1824. He also matured his investigation of the comet of 1680, and of the remarkable comet of short period which bears his name. Zach's Correspondence and Lindenau's Zeitschrift, about this period, contain many evidences of his talents and his industry. During his directorship of the Observatory at Seeberg he was elected an Honorary Associate of the Royal Astronomical Society, and at the time of his decease was the oldest foreign member on our list. In 1824 the Council of our Society awarded to Encke their gold medal for what Mr. Colebrooke, the President of that day, properly designated as "the greatest step that had been made in the astronomy of comets since the verification of Halley's Comet in 1759." Encke had long been on the track of his comet. In 1818 he had succeeded in identifying it with the Comet of Mechain and Mes-

sier in 1786, and again with the comet discovered by Miss Herschel in 1795, and with the comet of Pons in 1805. The result of his investigations was, that this comet, which astronomers have agreed to designate as "Encke's Comet" (although he himself always modestly calls it the Comet of Pons), would make its appearance again in 1822, although it would not then be visible in Europe. Accordingly our Society had the gratification of presenting to Mr. Rümker their medal for its discovery at Paramatta in 1822, on the same day when they bestowed a similar mark of approbation, as we have already stated, on Encke himself, for its prediction.

It was in these Memoirs, that Encke signalized himself by his systematic and most successful application of the *principle of least squares* to a number of astronomical observations. For the method itself we are mainly indebted to Legendre and to Gauss, but for the first exhibition of its vast practical value, we are indebted to the example of Encke. His mind, indeed, seems to have been preëminently arithmetical, delighting in the orderly and systematic development of what otherwise and to many would seem an inextricable maze of figures. Those who knew him best consider that he probably injured the generality of his mathematical analysis by the fastidious care which he bestowed upon its symmetrical arrangement.

In 1825, at the recommendation of Bessel, Encke was appointed to the Directorship of the Observatory at Berlin; the Observatory itself was both improperly situated, and inadequately supplied with instruments, but ultimately, at the suggestion of Humboldt, a new Observatory was erected at the expense of the Prussian government, Encke superintending personally both its construction and its interior arrangements. And here, for eight or ten years after its completion, he continued with much assiduity to observe both with the Transit Circle and the Equatorial; but his natural tastes did not lie in instrumental observations, and after the discovery of numerous small planets by various observers, he devoted himself with much success to the investigation of planetary disturbances.

The labors of Encke in reference to the comet which bears his name have already been referred to. Having carefully taken into account the perturbing action of the planets on this comet during several successive periods, he established the remarkable fact that there is some extraneous cause in operation which continually diminishes the comet's periodic time. This is evidently the effect which would be produced if the comet suffered a resistance from moving in a very rare ethereal medium, and accordingly this is the explanation proposed by Encke, and at present generally accepted by astronomers.

Encke has also, as already mentioned, devoted special attention to the subject of the perturbations of the Minor Planets.

In the Appendix to the *Berliner Jahrbuch* for 1837 and 1838, he expounds in detail the method of calculating these perturbations which had been long used by himself and other German astronomers, and which was originally given by Gauss. In this method the perturbations of the six elements of the orbit are computed for successive equal intervals of time by means of mechanical quadratures, and from the values of the elements thus found for any given time, the co-ordinates of the body at that time are determined.

Now this method, although a very beautiful one in theory, is attended with the disadvantage of requiring the determination of double the number of unknown quantities that are really wanted, and the calculations which must be gone through consequently become excessively long.

As the number of the known minor planets became larger, the want of a readier method of computing their perturbations became more and more pressing.

Encke was thus impelled to devise a mode of applying the method of integration by quadratures directly to the differential equations of motion of the disturbed body, and he published an account of this new method in the Proceedings of the Berlin Academy for 1851. In this Memoir he refers the place of the body to rectangular co-ordinates, and he determines the perturbations of its movements during successive short intervals of time by a direct computation of the changes produced in the three co-ordinates by the action of the disturbing planet.

He estimates that the labor of computation is reduced by the new method to less than one-half of that required by the method previously employed.

It should be remarked that Prof. G. P. Bond, in a paper which was communicated to the American Academy of Arts and Sciences in 1849, had already briefly explained a method of calculating perturbations exactly similar in principle to that of Prof. Encke, but the latter was totally unaware of the existence of this paper when he published his own Memoir, which enters much more fully into the practical details of the method, and gives greater prominence to the importance of it as applied to the case of the minor planets.

By astronomers of the present day it is possible that Encke may be most highly estimated for the vast improvements which he introduced into the Berlin Ephemeris. The history of astronomical ephemerides is not a little varied and curious; a concise account of it will be found in the fourth volume of the Memoirs of the Royal Astronomical Society, on the occasion of the council of the Society presenting Encke, through their President,

with a gold medal, for the part which he had taken in the improvement of the Berlin Ephemeris. Our own Nautical Almanac, at that day, viz. in 1830, had fallen or had remained greatly behind the requirements of astronomers; but in speaking of the merits of the foreign Ephemeris, the report of the Council runs as follows: "A gold medal has been voted to Professor Encke for the superb *Ephemeris of Berlin*. It would be superfluous to dwell upon the merits of this well-known work, which, far outstripping all rivalry, must be considered as the only Ephemeris on a level with the present wants of the sciences." On presenting the medal, Sir James South, the President, adds, "With the *Berlin Ephemeris*, an observatory scarcely wants a single book; without it, every one." It would, however, be disloyal, though in any other aspect it may be needless, not to add that what has just been said of the Berlin Ephemeris of 1830, may with equal truth be predicated of the Nautical Almanacs from 1834 to the present date; nevertheless the first impulse came from Encke and Berlin.

Many other labors of Encke may also be found in the Memoirs and Monthly Reports of the Berlin Academy, in the Astronomische Nachrichten, and in four volumes of the Berlin Observations. He is also well known by the publication of several excellent speeches, and especially for a memorable *éloge* on the celebrated Bessel.

Encke visited England in the autumn of 1840, in order to be present at the meeting of the British Association, and for the purpose of inspecting the English Observatories. His account of that journey is a testimony of the deep and pleasing impression which his hearty reception in England left upon his memory.

In 1859 Encke suffered from an apoplectic fit, and foreseeing the commencement of disease of the brain, he obtained leave of absence from his Observatory in the spring of 1863. In the autumn of the same year, finding a recurrence of the same symptoms, and knowing what they implied, with a brave heart, the now aged man explained his forebodings to a physician, and at once placed himself under his care in an institution for diseases of the brain at Kiel. At the commencement of 1864 he requested permission to be relieved from all astronomical work, and until the time of his decease, continued to live in a quiet, happy state of mind, in the midst of his family, at Spandau, near Berlin.

Encke, during the forty years of his professorship at Berlin, impressed the form and bent of his mind upon many pupils, who have ably contributed their share in the progress of astronomical knowledge. There is no greater proof of the real worth of a teacher, than when his pupils speak well and lovingly of him. They see the man in his weakness and in his strength. So it fared with Encke. They bear strong and uniform testi-

mony to his eminent frankness and truthfulness; his labors, they say, were incessant, his recreations few; he was simple in his manners, and in all his habits temperate. Towards his coadjutors and assistants he showed a severe judgment, but he set them a severer example. A man such as this, absorbed in his work, and shutting himself away from the outer world, was likely to be sometimes abrupt, or laconic, or even incautious, in his utterances; these utterances, from their bluntness or their truthfulness, occasionally gave offense, and involved Encke in trouble. As age, however, grew upon him he became more gentle in his manners, and softer in his address; and in the presence of those whom he knew and trusted, the old man would sometimes review his own life, and urge his favorite pupils to draw from his own experience lessons of moderation and self-restraint, both in passing their judgments on the labors of others, and in the amount of labor which they felt it their duty to exact from themselves.

There occurs but one more question regarding this great and venerable man; the writer of this memoir gladly adopts this language, *great and venerable*, because they are the very words selected by men who served him long and who knew him well, and who are themselves doing good public service in their own day. It is well known that great theological activity, not to say theological strife, surrounded Encke and every other intellectual thinker in Germany; it may not, perhaps, concern us, simply as students in Astronomy, but it cannot fail to interest us as men, to know what effect this independence of thought and boldness of expression had upon the spirit of a man, whose name will for ever be associated with some of the noblest and furthest-reaching efforts of the human mind. In reply to this question, we are told by those who knew him intimately, that Encke retained through life the strength and simplicity of his early faith; and we also learn that he was heard repeatedly to say, that one of the greatest pleasures of his life was derived from the fact, that one of his sons had become a minister of the Gospel. C. P.

ART. III.—*Sketch of the Geology of Northeastern Dakota, with a notice of a short visit to the celebrated Pipestone Quarry;* by F. V. HAYDEN.

THE object of this note is simply to record some observations on the geology of Northeastern Dakota, made by me in October last, together with an account of a short visit to the celebrated Pipestone quarry. No positive inference is drawn as to the age of the rocks in which the pipestone layer is located, from the fact that no well-defined organic remains could be found. Therefore certain facts are noted down with the hope that they may

hereafter aid in the solution of the problem of their age, inasmuch as their geographical distribution seems to be quite extended.

In October last, after my return from a tour of exploration to the "Mauvaises Terres" or "Bad Lands" of White river, I took advantage of an opportunity that presented itself to visit some portions of Dakota Territory on the north side of the Missouri river not hitherto examined by me. I there made my starting point the village of Yankton, the capital of Dakota Territory, located on the Missouri, about twelve miles above the mouth of the James. At this point we observed a large exposure of the yellow calcareous marl beds of No. 3, Niobrara Division, forming along the river nearly vertical bluffs, extending sometimes several miles. The rock varies in texture from a nearly white, soft chalk, much like our chalk of commerce, to a somewhat compact limestone which is used for burning into lime and for building purposes. Thick beds of this chalk present a marked rust color from the presence of a greater or less amount of the peroxyd of iron; otherwise it could hardly be distinguished from the chalk of Europe, and without doubt would serve the same economical purposes. The organic remains found here are not very numerous in species. The most abundant shell is the *Ostrea congesta* Conrad, which seems to have been as gregarious and to have aggregated together much in the same way as the little oyster which is exposed when the tide recedes along the shores of the Sea Islands of South Carolina. Near the base of No. 3, there are layers of rock several feet in thickness, made up almost entirely of one or more species of *Inoceramus*, one of which has been identified as *I. problematicus*. The fish remains are quite numerous, diffused throughout the rock. Fragments, consisting of jaws, ribs and scales, are found in the greatest abundance, and Mr. Propper, a resident of Yankton has succeeded in securing some nearly perfect specimens (undescribed) from the quarries there. This group of rocks extends for four hundred miles along the Missouri river, and I am convinced that when carefully studied, it will be found to represent the White Chalk beds of Europe, and be employed for similar economical purposes.

The Cretaceous rocks of the Missouri river have been numbered in the order of superposition, Nos. 1, 2, 3, 4, 5, and all of these divisions have been located in the geological scale by the unmistakable evidence of their organic remains. We find therefore that this portion of Dakota is occupied exclusively, or nearly so, by the middle member of the Cretaceous series. The soft and yielding nature of No. 3 is well shown by the topographical features of the country, where all the slopes are gentle in their descent, and for the most part covered with a thick

growth of grass; for the soil which is composed of the eroded materials of this group is quite fertile, and in ordinary seasons produces excellent crops, and is especially adapted to the growth of cereals.

From Yankton our course was nearly north, up the west side of James river. Our path led over a gently rolling prairie for sixty-five miles, with not a tree or a bush to greet the eye. There were no cut bluffs along the little streams over which we passed; the sides of the hills bordering the valleys sloping at a very moderate angle, and being covered with a thick growth of grass. No rocks were seen in place until we arrived at Fort James, about twelve miles below the mouth of Firesteel creek, a branch of James river. Erratic rocks of all sizes and texture were visible on the surface everywhere, more especially in the valley of James river and its tributaries.

At this point on James river, uncovered by the scooping out of the valley, is a large exposure of reddish variegated quartzites, differing somewhat in structure and appearance from any rocks hitherto observed by me on the Upper Missouri. They cover a considerable area in the valley of the James at certain localities, but nowhere are they exposed at a thickness of more than twenty or thirty feet. Indeed they have been much worn by water, so that they project above the surface in large square masses, suggesting to one in the distance a village of log houses.

The rocks are mostly reddish and flesh-colored quartzites, so compact that the lines of stratification are nearly obliterated. They also appear to be metamorphic. There is, however, a horizontal as well as a vertical fracture, and the horizontal fracture breaks across what appear to be original laminæ of deposition. These lines or bands are seldom horizontal; but much waved and inclined, as if the materials had been deposited in shoal or troubled waters. The illustrations of ripple or wave markings in these rocks are very numerous and beautiful. There is considerable variety in the texture of the rock; some of it is a very fine, close-grained quartzite, so that when worn by water it presents a smooth glistening surface like glass. Again it is filled with small water-worn pebbles, forming a fine pudding stone; again there are layers of siliceous sandstone, which separate into slabs varying from one fourth of an inch to several inches in thickness. This rock is very useful for building purposes, and has been employed at this point by the U. S. army officers in erecting the numerous buildings that constitute the fort. I looked diligently wherever the rock had been quarried, for some traces of organic remains, but none were visible. Resting upon the quartzite at this locality, is a bed of black plastic clay, precisely like No. 2 Cretaceous, as seen along the Missouri river near the mouth of the Vermilion. I found no fossils in this

rock, but there were numerous specimens of selenite in crystals, which characterize it in other localities. Resting on No. 2 is the Chalky marl of No. 3, not differing in structure from the same rock before described as occurring at Yankton on the Missouri river. It here contains an abundance of its characteristic fossil, *Ostrea congesta*. The thickness exposed is about fifty feet, but from an examination of the slope above, I estimated its entire thickness at this point at from 80 to 100 feet.

The formations at this locality, in descending order, are as follows: *a.* Yellow chalky marl No. 3; *b.* Black plastic clay with selenite crystals, undoubtedly No. 2; *c.* Reddish and rose-colored quartzites.

From Fort James we again proceeded across the undulating prairie, in a direction a little south of east, about 65 miles, to Fort Dakota, at Sioux Falls, on the Big Sioux river. Nothing of especial interest, in a geological point of view, met our eye except a small exposure of the reddish quartzite in the valley of Vermilion river. The soil of the prairie over which we passed, and also the superficial deposits as shown along the streams, gave unmistakable evidence that the surface features of all this region are due to the wearing away of the Cretaceous rocks Nos. 2 and 3, and that they are the immediate underlying formations. The most characteristic features which met the eye everywhere, were the boulders which cover large areas so thickly as to render cultivation impossible until they are removed. These rocks, however, will be found to be very useful to future settlers for building and other economical purposes.

At Sioux Falls there is a remarkable exhibition of the same red and variegated quartzites described at James river. They are here exposed only in the valley of the river by the removal of the superincumbent Cretaceous rocks. The falls are five or six in number, extending a distance of half a mile, and have a descent of 110 feet in all, forming the most valuable water power I have ever seen in the west. About ten feet from the top of the rocks as seen at this locality, is a layer of steatitic material, mottled, gray and cream-color, very soft, about 12 inches thick, which is used sometimes for the manufacture of pipes and other Indian ornaments. When the quartzites have been subjected to the attrition of water, they present the same smooth glassy surface as before mentioned. There are also beds of pudding stone, and the most beautiful illustrations of wave and ripple markings that I have ever observed in my geological explorations.

I was unable to discover any well defined fossils, but wherever the surfaces of the rocks had been made smooth by the attrition of water, quite distinct rounded outlines of what appeared to be bivalve shells could be seen, so numerous that the rocks must have been charged with them. The matrix is so

close grained and hard, that on breaking the rock no trace of the fossil could be found. I am confident, however, that the rock is filled with organic remains, but they cannot now be separated from the matrix so as to be identified.

From Sioux Falls to the celebrated Pipestone quarry, the distance is just 40 miles, measured with an odometer. Direction a little east of north. We passed over a similar undulating prairie, with but one small tree along the route, and but one rock exposure, and that occurs about four miles south of the quarry. The rock is a very hard quartzite, composed largely of water-worn pebbles, quartz, jasper, small clay nodules, chalcedony; some of the rock is a quartzose sandstone, other portions are fine grained siliceous rock. It lies in regular layers or beds, dipping at an angle of about 5°, 30° S. of E.*

On reaching the source of the Pipestone creek, in the valley of which the Pipestone bed is located, I was surprised to see how inconspicuous a place it is. Indeed, had I not known of the existence of a rock in this locality so celebrated in this region, I should have passed it by almost unnoticed. A single glance at the red quartzites here, assured me that these rocks were of the same age with those before mentioned at James and Vermilion rivers, and at Sioux Falls. The layer of Pipestone is about the lowest rock that can be seen. It rests upon a gray quartzite, and there are about five feet of the same gray quartzite above it, which have to be removed with great labor before the Pipestone can be secured. About 300 yards from the Pipestone exposure is an escarpment, or nearly vertical wall of variegated quartzite, extending directly across the valley. Each end of the wall passes from view beneath the superficial covering of the prairie. It is about half a mile in length. About a quarter of a mile farther up the valley there is another small escarpment, so that the entire thickness of the rock exposed at this point is about 50 feet. Not a tree can be seen; only a few small bushes growing among the rocks. There is a little stream of clear, pure water flowing from the rocks, with a perpendicular fall of about 30 feet, forming a beautiful cascade. The evidences of erosion were very marked, and the question arose—how could all the materials which must once have existed here joined on to these walls, have been removed, except by a stream much larger and more powerful in its erosive action than the one at present flowing here? There is a slight inclination of the beds from 1° to 3°, about 15° S. of E.

About 200 yards southeast of the quarry are five massive boulders, composed of a very coarse flesh-colored feldspathic granite, very much like that which forms the nucleus of the Black Hills.

* I am greatly indebted to Col. Knox, commandant of Fort Dakota, at Sioux Falls, for important facilities in my examinations.

The first detailed account of the Pipestone quarry that I have been able to find, is that of Catlin, in this Journal, [1], xxxviii. In Nicollet's excellent report there is a much more careful and accurate description of the rock and the locality, but neither of these gentlemen hint at the probable geological age. The first attempt to determine the age of the rocks in which the Pipestone is located, was made by Prof. Hall, in a paper read before the American Philosophical Society not long since. In that paper he regards them as of the same age with the Huronian rocks of Canada and Lake Superior.

At the time Mr. Catlin made his visit to the quarry he sent a portion of the pipestone to Prof. C. T. Jackson, of Boston, for analysis. Prof. J. gave it the name of Catlinite, with the following composition:

Water,	8·4
Silica,	48·2
Alumina,	28·2
Magnesia,	6·0
Peroxyd of iron,	5·0
Oxyd of manganese,	0·6
Carbonate of lime,	2·6
Loss (probably magnesia),	1·0
	100

The Pipestone layer, as seen at this point, is about 11 inches in thickness, only about 2¼ inches of which are used for manufacturing pipes and other ornaments. The remainder is too impure, slaty, fragile, &c. This rock possesses almost every color and texture, from a light cream to a deep red, depending upon the amount of peroxyd of iron. Some portions of it are soft, with a soapy feel, like steatite, others slaty, breaking into thin flakes; others mottled with red and gray. A ditch from four to six feet wide and about 500 yards in length, extending partly across the valley of Pipestone creek, reveals what has thus far been done in excavating the rock. There are indications of an unusual amount of labor on the part of the Indians in former years to secure the precious material.

This rock has been used for many years past by the Indians of the Northwest for the manufacture of pipes, and it was formerly the custom of some of the tribes to make the locality an annual visit to secure a portion of the precious material. They placed a higher value on the rock, because, while being so firm in texture it is so easily wrought, and because they could make far more beautiful and showy pipes than from any other material known to them. Besides, this was and is now, the only locality from whence the true pipestone can be obtained, and the labor is so great in throwing off the five feet of solid quartz-

ite that rests upon it, that the rock has always been rare. For a mile or two before reaching the quarry the prairie is strewed with fragments that have been cast away by pilgrims.

Nearly all of our writers on Indian history have invested this place with a number of legends or myths. They have represented the locality as having been known to the Indians from remote antiquity. All these notions, I am convinced, will disappear defore the light of a careful investigation of the facts. It is quite probable that the rock has not been known to the Indians more than eighty or one hundred years, and perhaps not even as long a period. I could not find a trace of a stone implement in the vicinity, nor could I hear that any had ever been found; and indeed nothing could be seen that would lead one to suppose that the place had been visited for a longer period than fifty years. All the excavations could have been made within that time. There are many rude iron tools scattered about, and some of them were taken out of the ditch last summer in a complete state of oxydation.

Again, it does not appear that in the mounds which have been opened in the Mississippi valley so extensively, any trace of this rock has ever been found. It is well known that the pipe is the most important of the dead man's possessions and is almost invariably buried with the body, and if a knowledge of this rock had extended back into the stone age, it is almost certain that some indications of it would have been brought to light in the vast number of mounds that have been opened in the valley of the Mississippi. Pipes and other ornaments, made from steatite, have been in use among Indians from the earliest indications of their history, and they are still manufactured from this material on the Pacific coast.

Now the question arises as to the age of the rocks we have attempted to describe and which include the pipestone layer. Owing to the absence of well defined organic remains, the problem becomes a difficult one. Their exceedingly close-grained, compact, apparently metamorphic character, would direct one's attention to the older rocks, perhaps some member of the Azoic series; but if the impressions seen at Sioux Falls are those of bivalve shells, we must look higher in the scale. But in order that we may arrive at an approximate conclusion, let us look at the geology of the surrounding country.

We already know that the limestones of the upper Coal Measures are exposed at Omaha City, and continue up the Missouri river to a point near De Soto, almost twenty miles farther, where they pass from view beneath the bed of the river. Overlapping them is a coarse sandstone composed of an aggregation of particles of quartz cemented with the peroxyd of iron. This assumes every color from a deep dull red to a nearly white. The layers

of deposition are very much inclined and distorted. Near Blackbird hill numerous dicotyledonous leaves have been found, and many of these plants occur in a quartzite so close-grained that the lines of stratification are nearly or quite obliterated, yet the impressions are distinct. This quartzite forms a valuable quarry near Sioux City. The coal seam included in this formation, (Lower Cretaceous, No. 1) crops out forty miles up the Big Sioux, or within sixty miles of Sioux Falls. Between Sioux City and Yankton we have at least three members of the Cretaceous series. Near Fort James we find that two members of the Cretaceous series (Nos. 2 and 3) rest upon the quartzites. The surface features of the whole country, with the soil and drift, indicate that the immediate underlying rocks are of Cretaceous age. Is it not possible therefore, that the quartzites that include the pipestone bed, belong to the supra-carboniferous, Triassic perhaps, or even to an extension downward of Cretaceous No. 1?

Prof. Hall, in an interesting geological memoir, read recently before the American Philosophical Society, gives an account of a tour into Western Minnesota, and many of the rock exposures which he describes must be of the same age with those noticed in this paper. He seems to have proceeded west from St. Paul to St. Peters and Fort Ridgely on the Minnesota river. From Fort Ridgely he continued west to Lake Shetek, which is not more than forty miles from the pipestone bed. Prof. Hall describes a wall of red quartzite at this locality, which he thinks is of the same age and character with that at Pipestone creek. I am convinced that not only the rock at Lake Shetek, but at many other localities which he describes with great care, are of the same age. I was informed by intelligent land surveyors in Dakota and Minnesota, that these red quartzite exposures extend very far to the north. Prof. Hall regards these quartzites as of the age of the Huronian series. His opportunities for tracing these rocks from the north and east were excellent, and his opinion is entitled to great weight.

Acad. Nat. Sci. Philadelphia, Nov. 10, 1866.

ART. IV.—*New Classification of Meteorites, with an Enumeration of Meteoric Species;* by CHARLES UPHAM SHEPARD.

THE arrangement here proposed differs so widely from the two formerly put forth by me, as to be really new. The changes introduced will, I trust, appear as flowing naturally from the recent progress of the study. The localities by which the system is illustrated are such as are represented in my collection, now deposited in Amherst College. A number of localities found on my previous lists as well as upon those of others, are omitted,

either because a degree of doubt hangs over their meteoric origin, or for the reason that they have suffered artificial alteration, or been too largely exposed to terrestrial decomposition.

CLASSIFICATION OF METEORITES.

CLASS I. **LITHOLITES.** Stoney. (Λίθος, *a stone.*)	Sub-Class 1. EUCRITIC. *Crystalline: earthy individuals distinct.* (Ευκρίτος, *distinct.*)	Ord. 1st. *Feldspathic.* Contains one or more species of feldspar. Ord. 2nd. *Augitic.* Contains augite.
	Sub-Class II. DYSCRITIC. *Earthy individuals indistinct.* (Δύσκρίτος, *indistinct.*)	Ord. 1st. *Psammitic.* (Ψάμμος, *sand.*) Has the structure of sandstone. Ord. 2nd. *Howardic.* Compactly massive. Ord. 3rd. *Oolitic.* With oolitic grains. Ord. 4th. *Porphyritic.* Sub-porphyritic. Ord. 5th. *Basaltic.* Trappean.
	Sub-Class III. ANTHRACIC. *Black.* (Ανθραξ, *coal.*)	Ord. 1st. *Atalene.* (Ατᾶλός, *soft.*) Friable. Ord. 2nd. *Anatalene.* (*a, privative* and ατᾶλός, *firm.*) Firm.
CLASS II. **LITHOSIDERITES.** Stone and iron, mixed. (Λιθος & Σιδηρος, iron.)	Sub Class I. PLEIOLITHIC. *More than half stoney.* (Πλείων, *more.*)	Ord. 1st. *Stigmatic.* (Στίγμα, *a spot.*) Iron in round spots.
	Sub-Class II. MEIOLITHIC. *Less than half stoney.* (Μείων, *less.*)	Ord. 1st. *Mignumic.* (Μίγνῦμί, *to mix.*) Stone and iron much mixed.
CLASS III. **SIDERITES.** Chiefly iron.	Sub-Class I. PSATHARIC. *Brittle.* (Ψαθαρός, *brittle.*)	Ord. 1st. *Chalyptic.* (Χάλψ, *steel.*) Steel-like.
	Sub-Class II. APSATHARIC. *Tough.* (Ἀψαθαρός, *tough.*)	Ord. 1st. *Agrammic.* Without lines when etched. Ord. 2nd. *Sporagrammic.* With scattered lines. Ord. 3rd. *Microgrammic.* Lines very small. Ord. 4th. *Eugrammic.* Lines distinct. Ord. 5th. *Megagrammic.* Lines coarse. [*and.*] Ord. 6th. *Tæniastic.* (Ταωια, *a rib-*Banded. Ord. 7th. *Nephelic.* (Νιφέλη, *a cloud.*) Clouded.

CLASS I. LITHOLITES.

SUB-CLASS I. EUCRITIC.

ORDER 1st. *Feldspathic.*

1. Stannern, Moravia, May 22, 1808.
2. Juvenas, France, June 15, 1821.
3. Jonzac, France, June 13, 1819.
4. Mässing, Bavaria, Dec. 13, 1803.
5. Petersburg, Tenn., U. S. A., Aug. 5, 1855.
6. Bialistock, Poland, Oct. 17, 1827.
7. Nobleboro, Maine, U. S. A., Aug. 7, 1823.
8. Manegaon, July 26, 1843.
9. Luotolaks, Finland, Dec. 13, 1813.

ORDER 2d. *Augitic.*

1. Chassigny, France, Oct. 3, 1815.
2. Bishopsville, S. Carolina, U. S. A., March 25, 1843.
3. Ensisheim, France, Nov. 7, 1492.
4. Shalka, India, Nov. 30, 1850.

SUB-CLASS. II. DYSCRITIC.

ORDER 1st. *Psammitic.*

1. Erxleben, Prussia, April 15, 1815.
2. Bethlehem, New York, U. S. A., Aug. 11, 1859.
3. Kleinwenden, Prussia, Sept. 16, 1843.
4. Simbirsk, Russia.
5. Pillistfer, Russia, Aug. 8, 1862.
6. Klein Menow, Mechlenburg, Oct. 7, 1861.

ORDER 2nd. *Howardic.*

1. Paulograd, Russia, May 19, 1826.
2. Zaborzika, Russia, April 10, 1818.
3. Mauerkirchen, Austria, Nov. 20, 1768.
4. Oesel, Baltic Sea, May 13, 1855.
5. Charkow, Russia, Oct. 13, 1787.
6. Linum, Prussia, Sept. 5, 1854.
7. Castine, Maine, U. S. A., May 20, 1848.
8. Alboreto, Italy, July, 1766.
9. Futtehpur, India, Nov. 30, 1822.
10. Kakova, Hungary, May 19, 1858.
11. Aumières, France, June 4, 1842
12. Utrecht, Holland, June 2, 1843
13. Lucé, France, Sept. 13, 1768.
14. Milena, Croatia, April 26, 1842.
15. Slobodka, Russia, Aug. 10, 1818.
16. New Concord, Ohio, U. S. A., May 1, 1860.
17. Girgenti, Sicily, Feb. 10, 1853.
18. Uden, Holland, June 12, 1840.
19. Buschof, Russia, June 2, 1863.
20. Angers, France, June 3, 1822.
21. Kuleschofka, Russia, Mar. 12–13, 1811.
22. Lissa, Bohemia, Sept. 3, 1808.
23. Bachmut, Russia, Sept. 15, 1814.
24. St. Denis, Belgium, June 7, 1855.
25. Apt, France, Oct. 8, 1803.
26. Linn, Iowa, U. S. A., Feb. 25, 1847.
27. Politz, Russian Germany, Oct. 13, 1819.
28. Nashville, Tenn., U. S. A., May, 9. 1827.
29. Forsyth, Georgia, U. S. A., May, 8, 1829.
30. Deal, New Jersey, U. S. A., Aug. 14, 1829.
31. Tirlemont, Belgium, Dec 7, 1863.
32. High Possil, Scotland, April 5, 1804.
33. Moradabad, India, Feb. 1808.
34. Durala, India, Feb. 18, 1815.
35. Yorkshire, Eng., Dec. 13, 1795.
36. Darmstadt, Hessia, 1815.

37. Nerft, Russia, April 12, 1864.
38. Macerata, Italy, May 8, 1846.
39. Dhurmsala, India, July 14, 1860.
40. Wessely, Moravia, Sept. 9, 1831.
41. Sales, France, March 8, 1798.
42. Favars, France, Oct. 21, 1844.
43. Heredia, Costa Rica, Apr. 1, 1857.
44. Vouillé, France, May 13, 1831.
45. Toulouse, France, April 10, 1812.
46. Constantinople, Turkey, June, 1805.
47. Grüneberg, Silesia, Prussia, Mar. 22, 1841.
48. Charsonville, France, Nov. 23, 1810.
49. Aigle (L'Aigle), France, April 26, 1803.
50. Charwallas, India, June 12, 1834.
51. Berlanguillas, Spain, July 8, 1811.
52. Goruckpore, India, May 12, 1861.
53. Macao, Brazil, Nov. 11, 1836.
54. Eichstadt, Bavaria, Feb. 19, 1785.
55. Agen, France, Sept. 5, 1814.
56. Château-Renard, France, June 12, 1841.
57. Doroninsk, Russia, Apr. 10, 1805.
58. Killeter, Ireland, April 29, 1844.
59. Shytal, India, Aug. 11, 1863.
60. Lixna, Russia, July 12, 1820.
61. Honolulu, Sandwich Isl'ds, Sept. 14, 1825.
62. Allessandria, Piedmont, Feb. 2, 1860.

ORDER 3rd. *Oolitic.*

1. Gutersloh, Prussia, April 17, 1851.
2. Nanjemoy, Maryland, U. S. A., Feb. 10, 1825.
3. Benares, India, Dec. 13, 1798.
4. Pulaski, Missouri, U. S. A., Feb. 13, 1839.
5. Nellore, India, Jan. 23, 1852.
6. Ausson, France, Dec. 9, 1858.
7. Timochin, Russia, March 13–25. 1807.
8. Trenzano, Italy, Nov. 12, 1856.
9. Pegu, India, Dec. 27, 1857.
10. Cereseto, Piedmont, July 17, 1840.
11. Esnaude, France, Aug. 1837.
12. Poltawa, Russia, anterior to 1838.
13. Zebrák, Bohemia, Oct. 14, 1824.
14. Ohaba, Transylvania, Oct. 10–11, 1857.
15. Casignano, Parma, Italy, April 19, 1808.

ORDER 4th. *Porphyritic.*

1. Assam, India. Found 1846 ?
2. Mëzo-Madaras, Transylvania, Sept. 4, 1852.
3. Chandakapoor, India, June 6, 1838.
4. Weston, Conn., U. S. A., Dec. 14, 1807.
5. Agra, India, March 28, 1860.
6. Siena, Tuscany, Italy, June 16, 1794.
7. Harrison, Kentucky, U. S. A., Mar. 26, 1859.
8. Richmond, Virginia, U. S. A., June 14, 1829.
9. Limerick, Ireland, Sept. 10, 1813.
10. Parnallee, India, Feb. 28, 1857.
11. Nulles, Spain, Nov. 5, 1851.
12. Abkurpore, India, April 18, 1838.
13. Cabarrus, N. Car., U. S. A., Oct. 31, 1849.
14. Okniny, Russia, Dec. 27, 1833.
15. Tabor, Bohemia, July 3, 1753.
16. Blansko, Moravia, Nov. 25, 1833.
17. Seres, Turkey, June, 1818.
18. Luponnas, France. Sept. 7, 1753.
19. Barbotan, France, July 24, 1790.
20. Tipperary, Ireland, Aug. 1810.
21. Bremevörde, Hannover, May 13, 1855.

ORDER 5th. *Basaltic.*

1. Chantonnay, France, Aug. 5, 1812.
2. Renazzo, Italy, Jan. 15, 1824.
3. Segowlee, India, March 6, 1853.
4. Mainz, Hessia. Found in 1852.

Sub-Class III. Anthracic.

Order 1st. *Atalene.*

1. Alais, France, March 15, 1806.
2. Orgueil, France, May 14, 1864.
3. Charleston, S. C., U. S. A., Nov. 16, 1857.

Order 2d. *Anatalene.*

1. Coll Bokkeveldt, Africa, Oct. 13, 1838.
2. Kaba, Hungary, April 15, 1857.
3. Grosnja, Caucasus, Russia, June 16, 1861.
4. Simonod, (Ain) France, Nov. 13, 1835.

CLASS II. LITHOSIDERITES.

Sub-Class I. Pleiolithic.

Order 1st. *Stigmatic.*

1. Hainholz, Westphalia. Found 1856.
2. Sierra de Chaco, Atacama, S. A. Found in 1862.

Sub-Class II. Meiolithic.

Order 1st. *Mignumic.*

1. Atacama, S. A. Found 1827.
2. Rittersgrün, Saxony. Found 1861.
3. Steinbach, Saxony. Found 1751
4. Krasnojarsk, Siberia. Found 1776.
5. Taney, Missouri, U. S. A. Found in 1856.
6. Newton, Ark., U. S. A. Found in 1860.

CLASS III. SIDERITES.

Sub-Class I. Psatharic.

Order 1st. *Chalyptic.*

1. Rutherford, N. Car., U. S. A. Found in 1856.
2. Niakornak, Greenland.
3. Newstead, Roxburgshire, Scotland. Found in 1861.
4. Otsego, N. Y., U. S. A. Found in 1845.

Sub-Class II. Apsatharic.

Order 1st. *Agrammic.*

1. Scriba, N. York, U. S. A. Found 1814.
2. Babb's Mill, Tenn., U. S. A. Found 1842.
3. Smithland, Kentucky, U. S. A. Found 1840.
4. Botetourt, Virginia, U. S. A. Found anterior to 1845.
5. Oktibbeha, Miss., U. S. A. Found in an Indian mound in 1856.
6. Wöhler's unknown locality.
7. Tucson, Sonora. Found 1850.

Order 2d. *Sporagrammic.*

1. Chester, S. Car., U. S. A. Found 1847.
2. Walker, Alabama, U. S. A. Found [in 1832.
3. Dacotah, U. S. A. Found 1833.
4. Rasgata, New Granada. Found 1823.

ORDER 3rd. *Microgrammic.*

1. Santa Rosa, (Coahuila) Saltillo, Mex. Found 1850.
2. Tocavita, near Tunga, New Grenada. Found 1823.
3. Braunau, Bohemia. Fell July 14, 1847.
4. Salt River, Kentucky, U. S. A. Found 1850.
5. Senegal, Africa. Found 1763.
6. Tucuman, Otumpa, Arg. Rep., S. A. Found 1788.
7. Bitburg, (Eifel) Prussia. Found 1814.
8. Bonanza, Mexico. Found 1865.

ORDER 4th. *Eugrammic.*

1. Oxtlahuaca, Mex. Found 1784.
2. Toluca, Mexico. Found 1784.
3. Maui (Toluca valley). Wöhler's 19 lb. mass.)
4. Ruff's Mountain, S. Car., U. S. A. Found 1850.
5. Marshall, Kentucky, U. S. A. Found 1856.
6. Schwetz, Prussia. Found 1850.
7. Cranbourne, Australia. Found 1861.
8. Robertson, Tenn., U.S.A. Found 1860.
9. Seneca Falls, N. York, U. S. A. Found 1850.
10. Orange River, Africa. Found 1856.
11. Oaxaca, Mexico. Found 1843.
12. Burlington, N. York, U. S. A. Found 1819.
13. Tula, Russia. Found 1846.
14. Wayne, Ohio, U. S. A. Found 1849.
15. Lenarto, Hungary. Found 1815.
16. Bohumilitz, Bohemia. Found 1829.
17. Texas (Red River), U.S.A. Found 1814.
18. Madoc, Canada. Found 1854.
19. Caillé, France. Found 1828.
20. Nebraska, U. S. A. Found 1856.
21. Lockport, N. York, U.S.A. Found 1818.
22. Oldham, Kentucky, U. S. A. Found 1860.
23. Durango, Mexico. Found 1811.
24. Carthage, Tenn., U.S. A. Found 1845.
25. Oregon, U. S. A. Found 1845.
26. Bahia, (Bendigo) Brazil.
27. Agram, Croatia. Fell May 26, 1751.
28. Ellogen, Bohemia. Found 1811.
29. Lion River, Africa. Found 1853.
30. Putnam, Georgia, U.S.A. Found 1839.
31. Aeriotopos,* near Denver City, Colorado. Found in 1866.
32. Asheville, N. Car., U.S.A. Found in 1839.
33. Guildford, N. Car., U.S.A. Found in 1828.
34. Tazewell, Tenn., U. S. A. Found in 1853.
35. Oberrkirchen, Nassau. Found in 1863.
36. Dickson, Tenn., U. S. A. Fell July 30, 1835.

ORDER 5th. *Megagrammic.*

1. Arva, Hungary. Found 1844.
2. Sarepta, Russia. Found 1854.
3. Zaccatécas, Mexico. Found 1792.
4. DeKalb, Tenn. Found 1845.
5. Cocke, (Sevier) Tenn., U. S. A. Found 184).
6. Heywood, N. Car., U.S.A. Found 1854.

* Αηριος, *lofty* and τοπος, *place*, from its being found over 8,000 feet above the sea.

ORDER 6th. *Tæniastic.*

1. Cape of Good Hope, Africa. Found 1801.

ORDER 7th. *Nephelic.*

1. Black Mountain, S. Car., U. S. A. Found 1835.
2. Seeläsgen, Prussia. Found 1847.
3. Nelson, Kentucky, U. S. A. Found 1856.
4. Union, Georgia, U. S. A. Found 1853.
5. Pittsburg, Penn., U. S. A. Found 1850.
6. Tabarz, Thuringia. Found 1854.

APPENDIX TO SUB-CLASS II. Markings not ascertained.

1. Savisavik, Greenland. Found 1850?
2. Benton, Texas, U. S. A. Found 1856.
3. Brazos, Texas, U. S. A. Found 1856.

Total number of localities in the collection, 211.

METEORIC MINERALS.*

1. CHAMASITE, (*Reichenbach.*) Fe, or variable mixtures of Fe and Ni up to 23 p. c. of the latter.
2. TÆNITE, (*Reichenbach.*) $Fe^x Ni^x$. ($Fe^4 Ni^2$. ?)†
3. OKTIBBEHITE, (*Shepard.*) Fe Ni.
4. SCHREIBERSITE, (*Haidinger.*) $Fe^x Ni^x P^x$ ($Fe^4 Ni^2 P$. ?)‡
5. RHABDITE, (*Reichenbach.*) $Fe^x Ni^x P^x$.
6. CHALYPITE, (*Shepard.*) $Fe^x C^x$. Forchhammer obtained as a leading constituent of the Niakornak Iron a hard, brittle, cast-iron like compound of iron and carbon in proportions of from 7·23 to 11·06 p. c. of carbon, which would indicate the formula of Fe^2C for this species.
7. FERROSILICITE, (*Shepard*). $Fe^6 Si$ (Si being 22).
8. TROILITE, (*Reichenbach*). $Fe^7 S^8$ (or Fe 62·07, S 37·93).
9. GRAPHITOID, (*Shepard*). $Fe^x C^x$ (nearly pure C).
10. KABAITE, (*Shepard*). $C^x H^x O^x$ (meteoric petroleum).
11. CHROMITE. Fe Ċr (with traces of Ṁg).
12. QUARTZ. S̈i.
13. OLIVINE. $Ḟe^2 S̈i + 9 Ṁg^2 S̈i$ (=S̈i 41·3, Ṁg 47·, Ḟe 10).
14. AUGITE or ENSTATITE. Ṁg S̈i (=S̈i 59·71, Ṁg 40·29).
15. PIDDINGTONITE, (*Haidinger*). $Ṙ S̈i + Ṙ^2 S̈i^3$ (=S̈i 57·66, Ḟe 20·65, Ṁg 19·, Ċa 1·5).
16. SHEPARDITE, (*Rose*). $Ṁg^2 S̈i^3$ (=S̈i 68·91, Ṁg 31·02.
17. ANORTHITE. $Ṙ Ä̇l S̈i^2$ (Ṙ being mostly Ċa, with a little Ṁg, Ṅa and Ṙ. Taking Ṙ as wholly Ċa, composition would be S̈i 45·8, Ä̇l 25·00 and Ċa 18·00.)
18. LABRADORITE. $Ṙ Ä̇l S̈i^2$. (Ṙ chiefly Ċa Ṅa and K̇. Composition nearly S̈i 53·09, Ä̇l 30·39, Ċa 16·52.)

* Only those species are enumerated which are supposed to have existed in meteorites anterior to their arrival within our atmosphere.

† I have observed in a single instance among the iron and nickel *matte* of the produce of the dipyrite mine at Gap, Penn., thin laminæ of an alloy of Fe and Ni precisely resembling the Tænite of meteoric iron, which consisted of Fe 56·11 and Ni 43·89.

‡ An artificial compound having this composition was produced by Deville.

Amherst College, Sept. 29, 1866.

ART. V.—*On the Tertiary Formations of Mississippi and Alabama;* by EUG. W. HILGARD, Ph.D., State Geologist of Mississippi.

PORTIONS of the Tertiary formations of Mississippi and Alabama have formed the subject of study of various observers, from time to time, during the past thirty-five years; and the relative age and characteristic fossils of three of the most important divisions, have been determined by the labors of Morton, Conrad, Lea, Lyell, Tuomey and others. Most of these observations, however, have been confined to a few localities, or to such as were situated at short distances from each other in the direction of the strike, though sometimes affording complete sections in that of the dip of the strata.

It is my object in the present paper, to review the general results of my own observations, as combined and collated with those of other scientific observers to whose writings I have been able to refer. If in so doing I am led to controvert the opinions of some, it is in the interest of science, my opportunities for observation having afforded fuller data for reaching correct conclusions. No one can appreciate more than I do, how much American geology owes to the indefatigable research of Conrad, especially. Had he been less active in promoting our systematic knowledge of the Tertiary, I should have had fewer objections to offer to his opinions, and certainly fewer results to science.

Among the sections best adapted to the study of the Alabama Tertiary, are those afforded along the course of the Alabama and Tombigby rivers, by the well-known exposures of Claiborne and St. Stephens, where Sir Charles Lyell first definitively settled the question of the age of the so-called Nummulite, more properly Orbitoides, limestone; and observed the fact, ignored again by some subsequent writers on the subject, that the matrix of Zeuglodon bones always lies below the true Orbitoides limestone.

The Vicksburg and Jackson groups.—In most respects, the Claiborne and the St. Stephens sections agree so closely, that their character was naturally considered as the type of the Southwestern Tertiary, until Conrad's examination of the Vicksburg bluff showed the *Orbitoides* to be there associated with a fauna distinct from, yet equalling in variety and peculiarity, that of the Claiborne sand. In view of the coincidence of leading fossils, nevertheless, Conrad at once considered the part of the Vicksburg profile first examined by him (No. 5 of Sec. 31, p. 141 of my Miss. Report) as the near congener of the Orbitoides limestone of St. Stephens. Yet he seems to have retained doubts as to the precise equivalence of the two divisions, which have lately found expression in the separation attempted by him, of the Vicksburg marl and blue limestone from the Orbitoides limestone proper,

and the transfer of the latter to the Jackson group. (This Jour., Jan., 1866.)

The collection of shells upon which Conrad based his determination of the latter group (Trans. Acad. Nat. Sci., 1855, p. 257) was unfortunately a selected one.* It led him to the conclusion that the Jackson beds contained no species in common with those of Vicksburg, and a very few with those of Claiborne. Had he been on the spot he would have found, as I did a few years afterwards, that not only do the Jackson beds contain a goodly proportion of recognized Vicksburg fossils, but that the same fauna (though in an indifferent state of preservation) occurs in the marlstone strata overlying the sandy shell-bed, associated with *Zeuglodon* bones, *Laganum Rogersi* and *Scutella Lyelli*. Moreover, the oyster occurring on top of the Jackson beds, as stated in a previous paper is not *O. Georgiana*, but a *Gryphaea* everywhere accompanying the *Zeuglodon;* but also occurring in the Vicksburg marl and limestone. Nowhere in Mississippi has a single Orbitoid been found associated with either the Zeuglodon, or any of the characteristic fossils of the Jackson group. It is quite possible that in Alabama, Zeuglodon bones may have been picked up in company with Orbitoids, equally as well as with drift pebbles. There, the same ravine often cuts into the strata of both groups, and of course commingles their fossils. In Mississippi, I have found this direct superposition only in a single instance; elsewhere, the regions in which the several groups crop out are so far separated geographically, (in consequence of the intercalation of lignitic strata,) as to leave the observer no legitimate chance of error in reference to fossils.

Notwithstanding the defectiveness of his materials, Conrad assigned to the Jackson group its proper place, between that represented by the Claiborne sands and the Orbitoides limestone. He still, however (*l. c.*) thought it most probable that the *Zeuglodon* was referable to the same age as the latter.

A great deal of the obscurity in which the relative age of the Southwestern Tertiary has been involved, is owing to too great a reliance placed by most observers on lithological characters,

* It is impossible to avoid erroneous inferences from the examination of fossils sent for determination by amateurs, and rarely collected with a view to completeness, or general results. From the collection of Jackson fossils submitted to Mr. Conrad, any one would infer that this rich fauna had been totally extinguished by some cataclysm, before the deposition of the Vicksburg strata; whereas in fact, probably more than one-fifth of the former fauna is represented in the latter.

The same has happened with reference to the superior Cretaceous of Mississippi and Alabama, the Ripley group of Conrad, whose fossils as described by him from a *selected* collection forwarded to him, would seem to constitute an isolated group, almost unconnected specifically, with the lower members of the Cretaceous of the Southwest and elsewhere; whereas in reality it shares the leading fossils of the latter, and is connected with the Rotten Limestone group especially, by transitions both lithological and paleontological, as ascertained by myself a year previous. (Miss. Rep., pp. 79, 84.)

differences as well as resemblances. The "white limestone of Alabama" has so long been quoted as the matrix of the *Zeuglodon* as well as of the *Orbitoides*, that no one seemed to question their being contemporaries. Yet in examining all the records of the occurrence of Zeuglodon bones which I have been able to collect, I have no where found a distinct statement that the Orbitoids have been found associated with them *in situ*. The Orbitoides limestone is mentioned as forming knolls, hill-tops—the *Zeuglodon* as being found in level fields, or in ravines.

The true position of the Zeuglodon bed did not, however, escape the glance of Lyell (On the Nummulite Limestone of Alabama; this Jour. [2], vol. iv); for he distinctly identifies the upper "Rotten limestone" bed of the Claiborne bluff with that which, at Bettis' Hill, contains *Aturea Alabamensis* and *Zeuglodon*, and underlies the Orbitoides rock. The only other observer who seems to have recognized the same fact, is C. S. Hale (this Jour., [2] vol. vi, p. 354). Tuomey, otherwise so accurate in his field observations, ignores it, and speaks only of the "white limestone" in general.

Nowhere has the geologist more need of divesting himself of reliance upon lithological characters, than in the study of the Mississippi Eocene. Not only do the materials of the different groups often bear a most extraordinary resemblance to each other, but their character varies incessantly *in one and the same stratum*, within short distances. Hale (*l. c.*) remarks that in Mississippi, the Orbitoides limestone seems to be represented by blue marlstone, and so it is—sometimes. But while on the one hand we see the hard limestone of the Vicksburg bluff passing into blue marl (Byram, Marshall's quarry), we on the other hand find it passing equally into a rock undistinguishable from that of St. Stephens (Brandon, Wayne county); the varied fossils described by Conrad disappearing almost entirely, to be replaced by millions of Orbitoids imbedded in a semi-indurate mass of carbonate of lime, interspersed at times with similarly constituted conglomeratic masses of *Pecten Poulsoni*.

I cannot therefore, with the lights before me, agree to the propriety of distinguishing as separate divisions the Orbitoides limestone and the Vicksburg group of fossils. Even the occurrence of a different species of Orbitoides (*O. nupera* Con.) at Vicksburg cannot alter the case, for the undoubted *O. Mantelli* occurs there also, in the solid rock. And there are few of the characteristic fossils of the Vicksburg profile, which I have not on some occasions found side by side with the *O. Mantelli* and its companions, the *Pecten Poulsoni* and *Ostrea Vicksburgensis*.

Of course, the coral had its favorite haunts—the mollusks theirs. There is nothing surprising in the fact that where the one abounds the others are usually scarce, or *vice versâ*.

The Red Bluff group.—In a late paper, above referred to, Conrad proposed to distinguish the lowest fossiliferous stratum ordinarily visible at Vicksburg, and subsequently studied by him (No. 4 of my Vicksburg section, *ut supra*), as a separate group, which he considers as characterized by the occurrence of *Ostrea Georgiana*, and for which he proposes the name of Shell Bluff group. I have elsewhere (this Jour., July, 1866) explained my reasons for dissenting from Conrad as to the position between the Claiborne and Jackson groups, which he assigns to this new division. To the propriety of distinguishing it, however, as a sub-group of the Vicksburg age, I fully agree, though doubting that of giving it the name of a locality from which, as Conrad remarks, but one coincident fossil is known—*O. Georgiana*—while another also occurring there—*O. sellæformis*—in Mississippi and Alabama is confined to the Claiborne group. In a profile of 80 feet, as occurring at Shell Bluff, loose data like those extant regarding this locality, cannot fairly be made a ground of conclusions contrary to the order elsewhere elaborately observed. For aught that is on record, the whole Jackson group may be represented between the beds in which *O. Georgiana* and *O. sellæformis* respectively occur at that place, if (as seems probable from its non-occurrence in the Jackson group of Mississippi and Alabama) the former shell should be so restricted in its range as Conrad supposes.

I believe the white limestone (No. 1 of my Vicksburg section) which underlies the lignite at Vicksburg, but is visible only at extraordinarily low stages of water, to be of the Jackson age, both from its stratigraphical position and the lithological character of the specimens I have seen. But whether it is or not, there can be no reasonable doubt that the usual Jackson strata, which are largely developed on the Yazoo above Vicksburg, underlie at Vicksburg, as well as on Pearl river and Chickasawhay, the Vicksburg group.

The Georgiana bed at Vicksburg is preëminently the habitat of a shell common to the Jackson and Vicksburg stages, but most abundant in the former, viz., *Meretrix Sobrina* Con.; of the two Madrepores described by Conrad, and of *Fulgoraria Mississip.*, all occurring, more or less, in the Vicksburg stage proper. Of the fossil first mentioned, I have after a freshet found hundreds washed out, mingled with numerous masses of Madrepores, sometimes of several pounds weight, with *Fulgoraria*, *Natica? Vicksburgensis*, *Ostrea Georgiana*, etc. The bed has therefore affinities both above and below, and moreover occupies precisely the stratigraphical position of the bed at Red Bluff (Miss. Rept., p. 135). Here the fossils are much more numerous and the affinities in both directions are therefore better expressed. Characteristic and abundant above all, however, is a *Plagiostoma*, which I

cannot distinguish from figures and descriptions of *P. dumosum*, but hesitate to refer to that species, since it has not been found in the underlying Jackson strata. Lyell mentions the occurrence of *P. dumosum* in the lower portion of the Orbitoides limestone at Bettis' Hill; the same is mentioned by Tuomey, moreover, as occupying a corresponding position in the St. Stephens profile, associated with Orbitoids, and even his description of the lithological character of the bed tallies with that of the Red Bluff deposit. Hale, likewise, mentions *P. dumosum* as one of the prominent fossils of the "white limestone."

The Red Bluff bed seems, therefore, to be more or less coëxtensive with the Vicksburg group, and regularly associated with it as a subordinate feature. Its inconsiderable thickness readily explains its entire absence at many points where, stratigraphically, it ought to appear. Unfortunately, the fossils accompanying *O. Georgiana* at the only locality, other than Vicksburg, where it has been found in Mississippi, have not been observed.

The Claiborne group proper.—That the beds of blue marl and white marlstone, which in my Report I have designated as the "Calcareous Claiborne" group, are strictly equivalent to the typical fossiliferous sand at Claiborne, with underlying limestone bed, is probable both from their stratigraphical position and the correspondence of all the fossils thus far observed; though from the indifferent state of preservation in which the latter are found in the Mississippi stratum, these are few in number. *Ostrea sellæformis* Con. and *O. divaricata* Lea, are the leading shells; I have also recognized *Corbula gibbosa* Lea and *Voluta petrosa* Con. These beds possess fewer good exposures in Mississippi than either of the preceding groups, and may possess many unobserved features. Since publishing my Report, I have received evidence that it extends somewhat farther westward, between the territory of the Jackson and Siliceous Claiborne groups, than it appears on the map. Nor is the division between it and latter groups very well defined, inasmuch as the transition from siliceous to calcareous materials is a gradual one, through strata often very rich in *Scutella Lyelli*, *Pecten Lyelli*, *Ostrea divaricata* and *O. Alabamensis* Tuo.? I am not aware of the existence of any lignite bed in the dark colored clays which immediately underlie the blue marl.

Siliceous Claiborne, or Buhrstone group.—The precise Alabamian equivalents of my "Siliceous Claiborne" group are not nearly so obvious. The extreme variability of its strata both in Mississippi and Alabama (see Tuomey's first Report, and C. S. Hale, *l. c.*), which it seems natural should carry with it a corresponding variation at least in the *predominance* of fossils, and the comparative scarcity and ill preservation of the latter, render its study doubly difficult. I think that, as Tuomey intimates

(ibid., p. 146) and Conrad more decidedly avers (this Jour., Sept. 1865, p. 266), there is a lower division to be distinguished, which represents the fauna of the Great Lignite epoch, while the upper one seems clearly to be the equivalent of the Buhrstone formation of Georgia and South Carolina. That here as elsewhere in the Mississippi Eocene, lignitic beds should intervene where there is a direct superposition in Alabama, need not surprise us.

Since publishing my Report, I have had some opportunity of examining more closely the southern portion of Newton and Lauderdale counties. I have ascertained that the facies of the white siliceous claystone, so remarkable for its lightness (Miss. Rep., p. 124), is much more extensively developed than I had anticipated; that though often showing lithological transitions into chert and sandstone, it is on the whole characteristic of the superior part of the siliceous division, whose lower portion is represented by the soft yellow sandstone of South Neshoba and North Newton, its lowest probably by the hard, buhrstone-like rock with chalcedonized shells, of the Marion ridge. (Ibid., *l. c.*) All this tallies very closely with Tuomey's observations in Alabama where the "chalk hills" are also a matter of popular remark.

Lower Lignite—Great Lignite group?—The fauna of the lower division, which has never been studied as yet, I conceive to be represented in the small fossiliferous sandstone deposits skirting the Cretaceous in Tippah and Pontotoc (Miss. Rep., pp. 109–112); in the isolated patch of ferruginous green sand of Shongalo, in Carroll, Holmes, Attala and Choctaw counties, Miss, which seems to have been struck again at 415 feet in the bored well at Jackson. (Ibid., pp. 121–123.) As regards this deposit, I will call attention to the fact that it contains *Aturea Alabamensis*, claimed by Conrad as a leading fossil of the Great Lignite, and moreover closely resembles in its lithological characters, the Shark river beds described by Meek and Hayden.

Finally, in Alabama, this era, as Conrad observes, is probably represented in the Bashia creek section of Tuomey's first Report; which, since it is said to contain abundance of well preserved fossils, is well worthy of especial study.

But from this point, Conrad, Hale and others have been led by lithological appearances to extend the limits of the Great Lignite to the southward and westward, to deposits far above it, and even, probably, beyond the limits of the Tertiary.

Conrad (this Jour., Sept., 1865) inclines to refer to this group the buried forest containing tree palms (Miss. Rep, 153), observed jointly by Harper and myself in 1855. The "Nipadites and Cycadites" of that locality, so far as any determination of specimens goes, were "all in the eye" of one of the observers. At all events, the bed lies above the Orbitoides limestone, and with-

in the Grand Gulf group of my Report; and the "large oyster" overlying marl and limestone, mentioned in the same place, is not *O. Georgiana*, but the *Gryphæa* repeatedly referred to. As for the Vicksburg lignite, it is but one of the many lignitic seams constantly found intercalated between the marine stages of the Mississippi Tertiary. Finally the Port Hudson strata, observed by Carpenter and Lyell, are either the highest of the Grand Gulf group, or form part of the (probably Post-pliocene) formation underlying the Mississippi delta—the "Coast Pliocene" of my Report.

Hale (this Jour., [2], vol. vi, p. 356) goes so far as to identify with the Bashia creek lignite, beds occurring near Natchitoches, and on the Trinity, Colorado and Brazos rivers, in Texas.

I shall not here reiterate the reasons and data given in my Report (p. 109) in support of my opinion that the whole of my "Northern Lignitic" is of the lowest Eocene age, having nothing new to add to what is said there on the subject, and by Dana. (Manual of Geology, p. 510.) In a late letter, Lesquereux informs me that according to the specimens he has examined, there must be a considerable difference of age between the Winston strata marked *c* in my general section (Miss. Rep., p. 108) and those marked *a* in Tippah, and that the former appear to be newer, probably Pliocene. Had the conclusion been the reverse, it might have been more readily reconciled with stratigraphical evidence. Winston county adjoins Neshoba, where, as in Lauderdale, the Lignitic unequivocally dips beneath the siliceous Claiborne strata, and the locality *c* is on the same parallel with the marine outlier of the Claiborne age, in Caroll and Attala. Between locality *c* and the edge of the siliceous Claiborne strata in Neshoba and Lauderdale, the outcrops continue in unbroken succession and uniformity of character; there is nothing to indicate the superimposition of a limited Pliocene basin upon the most ancient Eocene, *here*, any more than between loc. *a* in Tippah and *b* in Lafayette county, which latter Lesquereux is also inclined to consider of later age.

I hope to be able, hereafter, to submit to the experienced hands of Lesquereux more complete sets of specimens from these and other localities situated nearer to the recognized Eocene, with a view to the solution of the interesting problem regarding the correspondence of ancient and modern floras on the two continents.

It is the continuation of these lowest lignite beds of Lauderdale which, in the map accompanying Tuomey's first Alabama Report, is intended to be represented by a narrow band of brown tint, skirting the Cretaceous on the south, across the state. Tuomey was not certain of its eastward limit, and it would appear from the notes of Mr. Thornton, appended to Tuomey's second

Report, that on the line between the Cretaceous and Tertiary in Barbour county, Ala., no similar strata occur.

Stratigraphical conformation of the Tertiary.—I now turn to the consideration of some of the general stratigraphical phenomena of the Mississippi and Alabama Tertiary, which have given rise to misapprehensions regarding its dip and general arrangement.

I have stated (Miss. Rept., p. 107) that the general dip of the Tertiary strata of Mississippi seems to conform to that of the Cretaceous strata—westward in the northern part of the state, and southward, or nearly so, in the southern. The westward dip of the old Lignitic does not appear to be much greater than the fall of the rivers, from the fact that on the waters of the Tallahatchie and Yallabusha, the same strata appear in the beds of streams for miles, before giving place to higher ones. I do not think the dip can exceed four or five feet per mile; but the variability of materials and small extent of outcrops (which often exhibit local dislocations) render direct observations extremely difficult. As we approach the region of southward dip, however, the inclination becomes more decided and can be observed even in limited outcrops, on streams or railroad cuts trending southward. On Pearl river below Jackson, and on the Chickasawhay, there is no difficulty in recognizing the fact; but yet it is by no means easy to determine correctly the amount of dip, unless by regular leveling operations; the variability of the materials and thickness of the strata, as well as their irregular surface, rendering all the usual pocket instruments unreliable. According to the best observations I have been able to make by reference to the river level, the dip of the Vicksburg strata at Byram (Miss. Rep., p. 145) and of the Jackson strata near Trotter's plantation (ibid., p. 135) amounts to from 10 to 12 feet per mile, S. by W. But this is by no means the maximum or minimum observed, but refers to points where the great regularity of succession for a considerable distance seemed to indicate a normal configuration.

If this estimate be correct (and I do not believe it will hereafter be found to differ materially from the truth), it would go to prove that the upheaval which caused this dip as well as that of the Cretaceous system in Mississippi and Alabama, was a slow one. For the artesian borings on the territory of the former formation, have shown the dip to be about double the above, or 25 feet per mile, in Monroe and Lowndes counties, Miss., and the adjoining portions of Alabama. On the other hand, the strata of the formation overlying the marine Tertiary in south Mississippi possess so slight a dip as, at first, to render its very existence doubtful.

In the general (north and south) section accompanying Tuomey's geological maps of Alabama, the Tertiary strata are rep-

resented as dipping southward, conformably with those of the Cretaceous. Nevertheless, in the section from Baker's bluff to the lower Salt Works on the Tombigby, he finds the white limestone (= Jackson and Vicksburg groups) occupying "a trough-like depression in the Buhrstone formation." In conversations with me, a few months prior to his death, he expressed his belief that such was the general disposition of the Tertiary strata, and that on close examination it would turn out that the strata passed over in going southward from the border of the Cretaceous, would be again passed over in reversed order, still farther south. My report of the existence in Mississippi, of a lignitiferous formation (the Grand Gulf group) southward of the marine Tertiary, seemed to confirm this view.

My subsequent examination of the Mississippi Tertiary has proved that in Mississippi at least, the disposition is such as first conceived by Tuomey, and laid down on his map; affording a strong presumption that the same is the case in Alabama But at the same time I found, in two different meridians, a similar anomalous reappearance of older strata which had sunk out of view farther northward.

One of these cases is noticed in my Report (p. 128). From Jackson to Canton, a distance of twenty-five miles N. and S., the same clay marl stratum with *Zeuglodon* bones and *Gryphœa* continues on the surface, overlying conformably, as it seems, the lignitic strata, which appear in the bed of Pearl river, just above Jackson, overlaid by the shell-bed. But thence they sink out of view rapidly, and are followed in regular succession by the Jackson and Vicksburg strata. It will be remarked that here there is a singular elbow interrupting the regular E. by S. course of the strike.

The other case occurs on the Chickasawhay, contrary to the statement in my Report (*l. c.*), in making which I overlooked some specimens and notes of 1855, then mislaid.

I find that on the very southern edge of the Vicksburg territory in Wayne county, at Dr. E. A. Miller's (p. 146), I collected *Gastridium vetustum*, *Morio Petersoni*, *Laganum Rogersi* and other Jackson fossils, from a blue sandy marl directly underlying the St. Stephens limestone teeming with Orbitoids. North of this locality, the Vicksburg strata alone are seen outcropping until we reach Red Bluff, where the Jackson strata disappear beneath those of the Red Bluff group. Within this distance of about ten miles, not only have the Jackson strata "dipped up" again, but the Red Bluff group, with its concomitant green clays and stiff clay marls (nearly a 100 feet in thickness altogether) has vanished from between them and the Vicksburg strata proper. It might therefore be suspected that the whole formation was here thinning out, and that we were near the edge of a basin.

So far, I have been unable to observe the marine Tertiary in juxtaposition with the Grand Gulf group on the Chickasawhay, and cannot positively assert that the former dips under the latter at all. In Hinds, Rankin and Smith counties, their relative age is clearly exhibited, but it is possible that they do not overlap very far, so that, were a portion of the superior formation removed by denudation, the edge of the marine basin might be laid bare. Yet from the fact that at the very locality mentioned, the Vicksburg strata proper possess approximately the same aggregate thickness as elsewhere observed, we should not conclude that the stratum is about to run out. Nor is it easy to reconcile such a supposition with the grand scale on which these marine strata are developed in the direction of their strike, through the states of Alabama, Mississippi and Arkansas, and their relations to the Great Lignite. It would seem more natural to suppose that they form part of the deposits of a tertiary Gulf of Mexico, and now (either themselves or their deep sea equivalents) underlie that gulf. Under this point of view, they might possibly be expected to reappear in Yucatan, along the foot of the Mexican plateau, in Texas, and forming a tongue, as it were, in the direction of the long cretaceous Mediterranean, and tertiary freshwater sea which is marked by the Great Lignite of the upper Missouri.

In view of the slight dip of the Mississippi Tertiary, the anomalies mentioned may find their explanation in undulations of the sea-bottom upon which these strata were deposited. A dip of ten feet per mile does not differ very sensibly from the horizontal, and a stratum deposited on such a slope would not necessarily, on that account, vary much in thickness. If at the time of the deposition of the Jackson group, a northward slope to that extent existed between Jackson and Canton, a subsequent general upheaval to the northward would render that slope a horizontal plain, while the strata heretofore horizontal would acquire a southward dip to the same extent. Similarly, if between Baker's bluff and the Salt Works on the Tombigby, or between Dr. Miller's and Red Bluff on the Chickasawhay, the sea bottom had a slight trough-shaped undulation (such as the ocean beds of our time frequently exhibit), the existing state of things would result. Artesian borings lower down on the Tombigby river may hereafter inform us whether or not the white limestone underlies there, as by analogy with the Pearl river beds it might be expected.

While, however, the general features and position of the Tertiary as well as of the Cretaceous strata of Alabama correspond closely with those observed in Mississippi, it seems, contrary to what one would expect, that the absolute amount of southward dip is somewhat less in the former state. No numerical data re-

garding this point are given, but from the great breadth of country upon which outcrops of one and the same group of the Tertiary occur in Alabama, the fact is apparent enough as concerns the latter. Whether the same is true of any part of the Cretaceous, is doubtful; unless the great north and south width of the Ripley group, as exhibited on Chunnenugga ridge in Macon and Barbour counties (according to Tuomey's and Thornton's observations combined), should thus find its explanation. It seems doubtful, in fact, whether the true Rotten Limestone (if it exist there) comes to the surface at all. This is the more remarkable from the near proximity of the primary and metamorphic rocks of that portion of the state, whose original upthrusting would thus be proved to ante-date greatly the general Allegheny upheaval.

The Grand Gulf group.—I have considered the older and well-defined eocene Tertiary apart from the two other groups described in my Report, whose age is doubtful and whose relation to the former is not well recognized. A glance at the map nevertheless shows that so far as extent is concerned, the Grand Gulf group is perhaps the most important of the formations of the state of Mississippi, and that, judging by the trend of its outlines on the Mississippi river, it must be still more so in Louisiana; while in Alabama it rapidly contracts, and attracts so little attention that I find but two observers who, *passim*, advert to anything resembling this formation as it exists in Mississippi.

Conrad (this Jour., [2], vol. ii, 210) states that the bluffs of Vicksburg, Grand Gulf, Rodney and Natchez, have a similar geological origin; that their lower portion is of marine origin, and a member of the Eocene.

I am unable to refer to a prior publication, mentioned by Conrad, for the data upon which this determination is based, so far as the bluffs below Vicksburg are concerned. I have made detailed examinations of the profiles at Grand Gulf and at Fort Adams, at the extreme limits of the formation in Mississippi, and I may say, of all the important outcrops in the interior; but thus far, have failed to find even a trace of a marine fossil, and in fact, but a single specimen—a bone fragment as I take it—likely to prove of zoogene origin. Vestiges of vegetation are common, but only in one instance, so far, have I found any specimens likely to admit of exact determination. I refer to the deposit on the Chickasawhay, already referred to, which exhibits the trunks, stumps and roots of an ancient forest, inhabited, among other trees, by tree palms. But even here, scarcely anything beyond the most general outlines of a few leaves can be traced. It may be that in proximity to the (rare) lignite beds of this formation, better success might be had—as has been the case in the Lower Lignitic. In the sand- and claystones belonging

to this group, neither Wailes, who resided amongst them and gave the name of "Davion rock" to one variety of the former; nor myself who have delved in scores of exposures, have ever found a trace of any fossil whatsoever.

The Natchez bluff I have not visited; but Wailes, who resided within six miles of it, must have done so, and he is silent on the subject of any but the Loess fossils, although he mentions all other fossiliferous rocks occurring in the State. Thus, while I have seen mentioned in various places "marine strata at the foot of Natchez bluff," I cannot trace the report to any authentic source. I shall endeavor to settle the point as soon as possible, but meanwhile observe, that according to reliable information given me, the Rodney bluff is essentially a counterpart of that at Grand Gulf; a detailed profile of which, obtained at a medium stage of the river, is given in my Report (p. 148).

The extreme scarcity of fossils in this formation is the more remarkable, as from the regularity of its stratification it is manifest that it has been formed in quiet water, and it contains a great variety of materials suitable for the preservation of either fauna or flora. Even the strata containing carbonate of lime, however, seem to have had nothing to fossilize, save in the solitary instance of a doubtful fragment of cellular bone already mentioned. In some portions of it, we might imagine that the abundance of soluble salts (which pervade more or less the entire deposit) indicated the former existence of bitter lakes, incapable of harboring life; but this could by no means apply to the formation as a whole.

The only probable presumption in favor of referring it to the Eocene, so far as I know, arises from the lithological resemblance and transition of its strata, at its northern limit, to those of the Vicksburg group. The upper division of the latter group in the neighborhood of Brandon is undistinguishable from the materials of the Grand Gulf group at many points, and I so referred them until I found them overlaid by a string of limestone nodules containing *Orbitoides*, about forty-five feet above the uppermost sands of the Vicksburg group. (See section, Miss. Rep., p. 140.) At a level about forty feet higher, the characteristic soft white sandstone of the Grand Gulf group crops out.

This, however, amounts to mere conjecture; and, *per contra*, toward the sea-coast the lithological transition into the materials of the "Coast pliocene" seems about equally cogent. The mere fact that tree palms are found in the formation, amounts to nothing, inasmuch as these grow at the present time in the same latitude in South Carolina.

The existence of this formation in Alabama appears from Mr. Thornton's notes (2d Rep. Ala., Appendix), in which he mentions similar materials as overlying the (Vicksburg) marine Ter-

tiary at its southern limits. Moreover, Bigelow (this Jour., ii, 419) describes a sandstone formation in Baldwin county, Ala., which impresses me as though it might be Grand Gulf sandstone overlaid by the ferruginous sandstone with tubes, of the Orange Sand group (Miss. Rep., p. 9), "filled with variously colored sand." Bigelow states that in the lowest portion of this rock he has seen obscure impressions of shells; which, if my conjecture be correct, might offer an opportunity of determining the age of the group. The same rock is said to occur at Pensacola.

The "blue clay bottom" of the Coast—"Coast Pleiocene."—Finally, as regards the imperfectly known black clay formation of the coast (Miss. Rep., p. 154, ff.), a comparison of specimens of shells and borings obtained from the New Orleans artesian well,* in 1854, seems to show that it underlies the whole of the delta, perhaps as high up as Port Hudson, whose subterranean Cypress swamps, observed by Carpenter and by Lyell, may belong to this formation. No Eocene fossils have been brought up by the augur, even from the lowest shell-bed found, at the depth of 570 feet, (the greatest depth was 630); while from among the shells of the first bed struck, at 41 feet, I have thus far determined eighteen marine species, all now living in the Gulf. At 153 feet a trunk of cypress, with bark, was found. At 256 feet, some extinct, or if living, undescribed shells seem to occur; and at 480 a Gnathodon bed. I hope to be able to determine by microscopic comparison whether or not the Grand Gulf group has been passed through or reached in this bore, which from present appearances has penetrated both Post-pleiocene and Pleiocene marine deposits. This would parallelize more closely the Tertiary of the Atlantic coast and of the Gulf; though so far as I know, nothing apparently corresponding to the Grand Gulf era has been observed in the former series. Should the chain of the Antilles, after the close of the Eocene epoch have for some time cut off the Gulf of Mexico from the Atlantic, it seems possible that the deposits of the former might have changed their character to the extent required by the facts observed. A strong influx of fresh water—perhaps that pertaining to the Great Lignite era—from the continent might for the time being have extinguished the Eocene marine fauna without replacing it by another sufficiently numerous to be readily detected in the deposits of the period, which might thus correspond to the Atlantic Miocene. Upon the subsequent irruption of the Gulf stream through the Antilles chain, the formation of normal marine deposits along the margin of the Gulf would be resumed.

University of Mississippi, July 26, 1866.

* These specimens were furnished by Drs. Copes and S. S. Riddell, of New Orleans, to Maj. Gen. A. A. Humphreys, and by him referred to me for examination; which, however, is not yet completed.

Art. VI.—*Evidences of the existence of ancient Local Glaciers in the White Mountain Valleys;* by A. S. PACKARD, Jr., M.D.

THE following observations were made during the past autumn in the valleys of the tributaries of the Saco, and Androscoggin rivers. At Jackson, N. H., on Thorn mountain, which lies just south of Tin mountain, there are some well marked glacial scratches which point directly toward Mt. Washington, which stands at the head of the valley of the Ellis river; their course being N. 25° W. These were first noticed on quartz veins running over the ledges which have been polished smooth as porcelain and finely grooved. At other places on the same mountain part way up, and also upon the summit, upon removing the soil, similar striæ occurred running in the same direction. On this mountain and the neighboring hills occurred occasional boulders of a peculiar mica slate, enclosing crystals of staurotide, which had evidently been transported from near the summit of Mount Washington. The summit of Mt. Kearsage we found moulded by ice. Dr. C. T. Jackson in his report on the Geology of New Hampshire states that the drift scratches one half way up Mount Kearsage run N. 30° W. He also states that on Mount Chicorua they run N. 35° W. (S. 35° E.), which is the course of the Ossipee valley just below it.

On a hill just east of Goodrich's falls on the Ellis river are very distinct ice-marks, on polished surfaces, with striæ running N. 30° W., and lunoid furrows with their horns pointing up the valley in the same general direction as the grooves.

Crossing over the mountains into Chatham, and Stowe, Maine, into the valley of the Cold river, another tributary of the Saco, we find another set of striæ. The broad summit of Speckled mountain, opposite Mt. Royce, which two mountains guard the southern entrance of Evans' Notch, is glaciated both on the N.W. and N.E. flanks. Here also is a "col," down which the ice must have moved in both directions. Near the summit the grooves and lunoid furrows run N. 15° E., following the course of the valley at this place, and aiming at a higher peak to the north and east. On Mt. Baldface, 3600 feet high, three or four miles southward, the grooves are very clearly indicated both below and directly upon the summit. Here they run N. 10° W., and it might be mentioned that the Cold river valley turns more to the southeast at this point. On a shoulder of the mountain, perhaps 300 feet below the summit, the lunoid furrows are especially abundant.

On the summit of this mountain, which is made up of a light colored fine syenite, were a few boulders of a peculiar porphyritic syenite, with oblong crystals of albite. Following the N. 10° W. course, less than a quarter of a mile, we traced them to the

parent rock composing Peaked mountain, which is somewhat lower than Baldface, at least 100 feet.

Again, crossing the high range of mountains over into Gilead in the Androscoggin valley, glacial marks directed N.W. occurred on a high ledge near the river, indicating that the ice moved from the northwest, pursuing the general course of the valley at this point.

Here, then, are good proofs of distinct systems of glaciers radiating from a central *mer de glace* which capped the White mountains. This dome of ice must, so far as our slight observations show, have been soon subdivided into local glaciers which pursued their route down the different valleys to the sea. Thus following down the Androscoggin river, at Lewiston, the ice-marks run nearly north and south, the course of the valley at that place, as we are informed by Mr. G. J. Varney of that town; and at Brunswick, on the seashore, there are deep furrows running in a N.W. direction, being the ancient course of the river where it undoubtedly entered the sea, up to a late period of the Terrace epoch.

ART. VII.—*Experiments on the Electro-motive Force and the Resistance of a Galvanic Circuit;* by HERMANN HAUG.

[Concluded from vol. xlii, p. 389.]

NATURALLY I first inquired whether or not the experiments of other observers would exhibit peculiarities of a similar character. I am not fortunate enough now to have a great choice of material at hand. But the experiments of J. Müller, cited on page 384, with six cells of Daniell's, if every possible combination of two different intensities is calculated, show decidedly a similar great increase of the internal resistance with the decrease of the combined intensities, viz:

For cell	No.	1,	from	2·85	to 5·19
"	"	2	"	3·41	" 4·76
"	"	3	"	3·02	" 4·07
"	"	4	"	3·19	" 4·07
"	"	5	"	3·08	" 4·73
"	"	6	"	3·68	" 4·19

As I have every reason to believe that in these experiments the circuit was really opened every time a greater resistance was to be introduced, I considered this circumstance, or the reverse, as not of any great account, and tried to determine at least the general character of its influence upon the results of all the other circumstances which may be regarded as important.

With this object in view, I preferred to exchange the nitric acid for a properly acidulated solution of bichromate of potash, since a battery with this liquid, after having been used for some time, possesses much less reliability as regards constancy than the Bunsen battery. The results of this series of experiments are recorded in table VI. They are very irregular, from errors of observation, and from what are called the fluctuations of the electro-motive force. For every external resistance two mean values of the internal resistance are calculated, one from the first half, the other from the second half of the single observations. These mean values are:

For centim. of platinum in the circuit.	First mean value.	Second mean value.	For centim. of platinum in the circuit.	First mean value.	Second mean value.
2	25·69	25·00	30	37·33	34·37
4	36·5	28·42	40	34·72	36·09
6	33·34	31·08	60	41·37	39·76
8	33·44	31·69	120	41·85	39·57
10	31·36	31·75	200	41·54	40·09
20	35·27	34·66			

In nine out of eleven cases the mean values of the first observations are greater than the mean values of the last observations. From this fact I thought myself warranted to believe that all those circumstances together which may be considered as influential upon the results, generally tend to diminish the ratio of increase, or at least, that in my experiments they would not increase this ratio. I therefore considered the results of my experiments reliable enough, as far as the fact of the great increase of internal resistance was concerned, and I changed only the manner of determining the intensity by observing the deflections of the swinging needle, both ways, and taking the mean, instead of waiting for the resting of the needle. In this way I made two series of observations, the results of which are given in tables VII and VIII. The battery was Bunsen's, the acids having been used once before.

Since the heating of the thin platinum wire of the reochord prevented me from observing higher intensities (those above tan. = 0·6), and calculating upon them, and since I was aware that the influence of temperature upon the resistance of conductors would probably be, and has been, considered as sufficient to explain the increase of internal resistance, as proceeding from the common method of calculation, I prepared myself a rather imperfect reochord with copper wire, because this metal becomes heated but very little, and would afford me to compare the results of very different intensities. Table VII contains the results of experiments with this copper wire rheochord. All resistances are expressed in centimeters of this copper wire. Experiments of table VIII are made with the platinum wire rheo-

chord, besides which the circuit constantly contained 200 centimeters of thin copper wire. As to the calculation of the internal resistance I have to make the following statements.

The vertical columns (*a*) of both tables exhibit this resistance when calculated after the common rule, viz: combining the direct intensity with every lower intensity.

In table VII, the column (*a*) gives an increase of internal resistance, if only the mean values of the first, and last, five observations are taken, from 103·95 to 128·51, or from 1 to 1·24. In table VIII, the corresponding column (*a*) gives, from the first and last, three values, an increase from 6·5 to 10·55, or from 1 to 1·61. For the whole range of intensities, between the limits 1·982 and 0·7844, the increase of resistance therefore is as 1 to $1{\cdot}24 \times 1{\cdot}61$, or as 1 to 1·996. The two centimeters of platinum wire were far from being red hot, yet it is difficult to decide, whether or not, this increase can be explained simply by the influence of temperature, the latter not being determined. I thus failed to get a direct proof that the increase of internal resistance, as visible after this way of calculation, is decidedly greater than the temperature of the measuring wire could account for.

But thinking the matter over I found why this way of calculation is wrong. The first direct observation belongs to a circuit, with high intensity, and where there is no part of it heated considerably. With this observation there are to be combined, first, the observation of an intensity somewhat lower, but the measuring part of the circuit heated very much; second, the observation of a low intensity within a circuit heated but very little. It seems evident both as regards the influence of temperature, and as regards the supposed influence of the intensity of the current, upon the internal resistance, that in this way matters become rather mixed up, and mean results are arrived at, instead of the extreme values sought after. To study the influence of temperature, of intensity of the current, upon the internal resistance, requires therefore to combine with each other, first, two observations of high intensities in circuits, with the measuring unit of resistance heated considerably; and second, two observations of low intensities at which this unit of resistance is heated but very little. Estimating then the ratio of increase, due to the difference of temperature of the unit of resistance, the quotient of it into the actual ratio of increase will give the ratio of increase of the internal resistance, due to the difference of intensity of the current. Of course, it would be much better to provide means for keeping the unit of resistance at constant temperature, but I refer to the method of determining the constants of the battery as commonly practiced.

In order to eliminate as much as possible, the errors of obser-

vation I preferred to calculate upon the combination of every two intensities. The results are contained in the vertical columns to the right of columns (*a*), of tables VII and VIII. In table VII, I further calculated the mean of the last five values of each vertical column from (*a*) to (*b*); and the mean value of all the other figures. The table shows unmistakably a general and great increase of the internal resistance with decrease of observed intensities. Comparing now the mean of the first five values of column (*a*), not with the mean of column (*b*) which may be too high, but with the mean of all the last figures, which is still less than the mean of 171·6 and 198·9; we get a ratio of increase of from 103·91 to 183·6; or 1 to 1·77; and this for a reduction of intensity from 1·982 to ·7844, or from 2·53 to 1; and for a reduction of temperature of the unit of copper wire which I should not think at all sufficient to explain that ratio.

In table VIII, calculated in the same way, the mean values at the foot of it embrace only the last three figures of each column. Comparing here the mean of the first three figures of column (*a*) with the mean of the last two mean values, viz: $\frac{15{\cdot}81+18{\cdot}35}{2}=17{\cdot}08$, in order to avoid any overrating, we get an increase of from 6·5 to 17·08, or from 1 to 2·63, which again cannot be accounted for solely by the difference of temperature of the unit of resistance. This ratio is therefore partly due to the ratio of decrease of intensity of the current which amounts to $\frac{{\cdot}7844}{{\cdot}091}$, equal 8·62 to 1.

In table VII, with the copper wire rheochord, a reduction of intensity to $\frac{1}{2{\cdot}53}$, and of temperature of the rheochord wire to an unknown extent, are attended with an increase of internal resistance from 1 to 1·77. In table VIII, with the platinum wire rheochord, a reduction of intensity to $\frac{1}{8{\cdot}62}$, and of temperature of the rheochord wire to an extent much greater, I have no doubt, than in case of the copper wire, is followed by an increase of internal resistance not more than from 1 to 2·63, being less, in proportion, than in case of table VII. It therefore seems that the increase of internal resistance, as proceeding from difference of intensities, is greater at high intensities than at low intensities of the current. And combining now the results of both tables, we find an increase of internal resistance from 1 to $1{\cdot}77\times 2{\cdot}63$, or from 1 to 4·655, this increase being due first to the reduction of intensity from 1·982 to ·091, and second to the difference of temperature of the unit of resistance, which however could not produce half that ratio, I should think.

In computing these figures I made use of the values of columns (*a*), after having raised objections against them. But it seems to me that I thereby did not unduly increase the results, attributing them as I do to the full difference of intensities, and to the difference of temperature as proceeding from the second intensity and the lowest. Considering this circumstance as chiefly affecting the results of columns (*a*), it appears also evident that the increase of resistance within this column is not so much the result of difference of temperature, as of difference of intensity, since the influence of intensity starts from 1·982 in table VII, and 0·7844 in table VIII, while the influence of temperature starts in correspondence with intensity 1·8008 in table VII, and 0·6063 in table VIII.

There is another circumstance connected with table VIII, the experiments having been made with a circuit containing constantly 200 centimeters of thin copper wire, as an addition to the internal resistance. If the resistance of this copper wire, and the true internal resistance are calculated separately, by means of combining the two first intensities with each of the following ones, there result values contained in columns (Cu) and (R). Both of them show the same ratio of increase as column (*a*), confirming the fact as exhibited in table V. Thus far, the addition of the 200 centimeters of copper wire to the internal resistance proper, does not seem to modify the ratio of increase.

The experiments for tables VII and VIII, still were rather unsatisfactory, showing too great irregularities. To avoid them, if possible, and with a view to get a clue to the understanding of the matter, I undertook another series of experiments, with as much care as I could afford, and the instruments at my command would allow. I made four pairs of observations, two for each end of the swinging needle alternately, and took the mean value of them. The battery was a Bunsen's; the diluted sulphuric acid containing rather much sulphate of zinc, and the nitric acid having been used for a short time. Using such acids my object was plainly to get results about facts of ordinary occurrence. I tried the battery first without any unnecessary addition of other resistances than the platinum rheochord, and afterwards with an addition of 25, 50, 100, 150, 200 centimeters of thin copper wire. The results of these observations, calculated in the same way as explained for tables VII and VIII, are recorded in tables IX to XIV. I did not succeed, the results remaining irregular, probably partly from constant faults of the instruments, and of the location of the tangent compass within about 15 feet distance from an iron stove, and within about five feet distance from about five pounds of iron which could not be removed. I therefore had to content myself with these results, and to use them with caution.

In table IX, the mean of the first three values of column (*a*)

is 3·21; the mean of the last three values of the same column is 6·34. The increase is in the ratio of 1 to 1·975. Leaving out the value of column (*b*), as too low, but taking the mean of the six mean values to the left of column (*b*), from 17·31 to 23·03 there being three small and three large values, we get an increase of internal resistance from 3·21 to 18·51, or from 1 to 5·77. This increase is due to the reduction of intensity from 1·3422 to 0·0581, and to the reduction of temperature of the unit of resistance, from dark red heat of the 6 cm. of platinum wire, to about the temperature of the air.

It may be well to examine with some detail this series of observations. The battery was in such a state that the direct intensity decreased rapidly during the short time necessary for 4 pairs of observations of the needle. The intensity with any length of platinum wire in the circuit, was variable too, becoming diminished with short length, and increased with great length of the wire. The examination of the following figures will give an idea of the amount of this variation of intensity. They are the mean values for the first, respectively for the second two pairs of observations:

Cent. of plat. wire in the circuit.	Intensities.		Cent. of plat. wire in the circuit.	Intensities.	
	First.	Later.		First.	Later.
0	1·5039	1·3605	50	·1437	·1441
6	·4679	·4665	60	·1267	·1259
8	·4119	·4097	70	·1118	·1130
10	·3721	·3729	80	·1000	·1016
12	·3402	·3424	90	·0898	·0919
14	·3177	·3153	100	·0814	·0840
16	·2929	·2934	110	·0748	·0774
18	·2762	·2783	120	·0705	·0726
20	·2594	·2596	130	·0652	·0677
30	·2052	·2048	140	·0608	·0634
40	·1674	·1700	150	·0567	·0585

Owing to this change of intensity, it would be necessary to calculate upon the first observations rather than upon any later ones, or upon some mean values. If I do so, I get in column (*a*), 3·01 and 5·89 as mean values, with an increase from 1 to 1·957; instead of the above values 3·21 and 6·34, with an increase from 1 to 1·975. The true ratio of increase is therefore somewhat less than calculated from the table, and this holds good for the whole ratio of increase.

On the other hand, if the decrease of intensity with the time, is mainly to be assigned, as probably will be maintained, to some polarization having taken place, which, from the high direct intensity to the next with 6 cm. of platinum wire in the circuit, will be kept for some time near its maximum; then the intensity with 6 cm. of rheochord wire is lower than it would be, had the circuit not been closed, directly and constantly, previous to the observation with 6 cm. of platinum wire, since this low

intensity cannot possibly produce the maximum of polarization. Assuming therefore the intensities with 6, 8 and 10 cm. of platinum wire too low, the mean value in column (*a*) would become yet smaller than 3·01, and the ratio of increase of resistance therefore greater than 1·957, if not greater than 1·975. And this again holds good for the whole ratio of increase.

Considering all these circumstances, I think that my discussion of the combined results, from table VI, is not much at variance with the truth, and that my figures do not exaggerate the facts in any high degree.

There is an other point to be considered. The decrease of intensity with 6, 8 and 10 cm. of rheochord wire in the circuit amounts to a mean of 0·0013. When the circuit is closed directly, this decrease of intensity, for about the same time, amounts to 0·1434, that is, to many times more than the difference of intensities amounts to. The intensity 1·5039 within the circuit closed directly, is the mean value of two pairs of observations, one for each end of the needle, being respectively 1·5845 and 1·4233, with a decrease of 0·1612. This rapid decrease of intensity would justify starting the calculation of column (*a*) from the direct intensity 1·5845 instead of from any later intensity, or from any mean value. If I do so, and compare this intensity with the first intensities given above, the mean values for the first and for the last three figures of column (*a*) become 2·80, respectively 5·58, the ratio of increase being 1·993 against 1·975 from the table. And the whole ratio of increase of resistance would become $\frac{3{\cdot}21}{2{\cdot}80}=1{\cdot}1465$ times greater than was resulting from the table. This increase, due to the greater direct intensity started from, exemplifies however the intensive degree of influence of the intensity of the current upon the internal resistance, as compared with the influence of the temperature of the unit of resistance.

I suppose, after all, that one may possibly consider the great ratio of increase of internal resistance as figured from table IX, to be the consequence, to a great extent of polarization to which any inconstancy of a battery is usually assigned, and the battery was in fact rather inconstant. But apart from my above reasoning to the contrary, I can refer to table I, the experiments for this table having been made with a battery the acids of which had been used for but a very short time. The degree of constancy of this battery may be judged from the fact that the compass needle was at 60·8° at the beginning of the experiments and at 60·2° one hour later, during which time the battery had been in use, except for very few minutes. Now, if I combine the intensities for several great resistances in the circuit, and take the mean of three consecutive values, I get 15·65, 19·46,

24·97, 17·92, as internal resistances. The mean value of all of them is 19·5, and the internal resistance as calculated from the direct intensity, and that with 8 cm. of platinum wire in the circuit, being 3·48, there results an increase from 1 to 5·604, without the platinum being red hot, against 5·77 of table IX, with the platinum wire red hot indeed. At any rate the polarization cannot play a great part in the results of my experiments.

Comparing the results of tables IX to XIV, I get from the mean values the following

Table of ratio of increase of Internal Resistance, with constant addition of different lengths of copper wire in the circuit.

Length of copper wire in the circuit.	Resistances of columns (*a*)		Ratio of increase.	Mean highest resistances.	Total ratio of increase.
	Lowest.	Higher.			
0	3·21	6·34	1·975	18·51	5·77
25 cm.	3·88	7·77	2·003*	20·17	5·20
50 "	4·33	8·49	1·961	20·67	4·77
100 "	5·02	9·79	1·95	21·30	4·24
150 "	6·61	11·66	1·764	22·24	3·36
200 "	7·65	12·94	1·691	23·44	3·06

The table illustrates the dependence of the ratio of increase on the manner the directly closed circuit is built up, on the greater or less intimacy of the contact, etc.

In tables X to XIV, column (Cu) contains the resistances of the respective lengths of copper wire. The increase of resistance maintains the same ratio as in the respective columns (*a*). Using mean values, I derive, from comparing all five tables, the following results.

Length of copper wire.	Resistance at high intensity.	Respective resistance of 25 cm. length	Resistance at low intensity.	Respective resistance of 25 cm length.
25 cm.	·50	·50	·993	·993
50 "	·85	·425	1·666	·833
100 "	1·66	·415	3·237	·809
150 "	2·76	·46	4·877	·813
200 "	3·62	·452	6·12	·765

The resistance of 25 cm. of copper wire, expressed in centimeters of platinum wire, at high intensity, is rather irregular, the first value in particular being too great. It is, however, in agreement with all other facts, safe to say that the resistance of a given length of copper wire, or the specific resistance, appears the greater the longer the measured wire is. This is contrary to what may be expected from the different influence of temperature upon the resistances of copper and platinum, exemplifying again the supposition that there is some other reason for the increase of resistance in columns (*a*), overruling the influence of difference of temperature. At low intensities, the specific re-

* The observation with 25 cm. of copper and 4 cm. of platinum wire in the circuit, gives a ratio of increase comparatively too great, on account of this length of platinum wire having been hotter than in any other case.

sistance of the copper is actually decreasing with the length of the measured wire, and this seems to indicate that at low intensities, the influence of temperature upon the resistance of conductors prevails over any other reason which, in a galvanic battery, and with this method of determination and calculation, may modify the resistances, actually or apparently.

It was desirable to determine the resistance of the copper wire at low intensities, without any interference on the part of high intensities. The last observation of each of the tables XII to XIV, each with 100 cm. of platinum but with no copper wire in the circuit, enabled me to do so. From

$$I_1=\frac{E}{W+C+P_1};\ I_2=\frac{E}{W+C+P_2} \text{ and } I_3=\frac{E}{W+P_3}, \text{ there follows}$$

$$C=\frac{P_3I_3(I_1-I_2)-P_2I_2(I_1-I_3)+P_1I_1(I_2-I_3)}{I_3(I_1-I_2)}.$$

Putting $I_1=0{\cdot}1900$, $P_1=30$; $I_3=0{\cdot}0832$, $P_3=100$, and afterwards " $=0{\cdot}1580$, " $=40$; " = " " = " all from table XII, and combining them successively with each of the observations with from 50 to 100 cm. of platinum, and 100 cm. of copper wire in the circuit, as per table XII; and further calculating, after the same manner, with the corresponding figures of tables XIII and XIV, there result, as the mean values from 12 single ones, the following resistances:

Length of copper wire.	Resistance.	Resistance of 25 cm. length.
100	4·465	1·116
150	5·128	0·855
200	5·125	0·641

It becomes here more evident that at low intensities the specific resistance of the copper wire appears to increase with the intensity, respectively with the temperature produced by it.

Of course the above figures cannot be compared with those given on page 50, since the latter values were derived from the highest direct intensity. In order to connect the results of both calculations, I combined first, the intensities 0·8865 and 0·0832, and afterwards the intensities 0·373 and 0·0832, with each of the six observations before the last, all of table XII. The values resulting therefrom, in columns 1 and 2 of the following table, compared with those in columns 3 and 4, which the above mean value (4·465) is derived from, go again to show a general de-

1.	2.	3.	4.
12·3	7·74	4·84	3·53
9·74	6·62	4·73	4·19
7·13	5·02	3·66	3·25
6·35	5·81	5·27	5·19
5·08	4·73	4·53	4·49
4·49	4·78	4·93	4·95
	Mean,	4·66	4·27

crease of resistance of the copper wire with decrease of observed intensities, the last horizontal row of figures making the only exception, if one and the same low intensity is considered. The values in columns 3 and 4, do not decrease, on account of errors of observations, I suppose. If calculated for table XIII, column 3 is decreasing, column 4 increasing. If calculated for table XIV, both columns 3 and 4 are decreasing, from the mean of the first three values to the mean of the last three.

It seems to me that the facts here illustrated, give a new reason for the great difference of the specific resistances of conductors, as derived by different observers from experiments, under conditions much varying and either partly unknown, or at least underrated in their influence. From observations of Davy, Becquerel, Ohm, Christie, Lenz, Pouillet, Buff, Frick, Müller, Lamy, Arndtsen, Matthiessen and Wiedemann, as recorded in G. Wiedemann's Galvanism, 1863, I extract the following table of the extreme values of the conducting power of different metals, for which the conducting power of silver is taken as 100. The values vary

For copper	between	the	limits	65·8	and	280·9,	ratio 1	to 4·27
" gold	"	"	"	55·2	"	161·8,	" 1	" 2·93
" zinc	"	"	"	24·06	"	93·6,	" 1	" 3·88
" tin	"	"	"	11·45	"	47·2,	" 1	" 4·12
" iron	"	"	"	12·35	"	48·9,	" 1	" 3·96
" platinum	"	"	"	7·93	"	48·0,	" 1	" 6·05
" lead	"	"	"	7·77	"	63·3,	" 1	" 8·15
" antimony	"	"	"	4·29	"	6·5,	" 1	" 1·51
" mercury	"	"	"	1·63	"	4·62,	" 1	" 2·83
" bismuth	"	"	"	1·19	"	1·9,	" 1	" 1·6

While the method of calculation of columns (Cu), (R) and (a), of tables X to XIV, gave the appearance of the ratio of increase being equal for the whole amount, and every part, of the so-called internal resistance, the copper wire included, the above computations show that, for low intensities, the copper wire follows its own rate of increase, or rather decrease, leaving indeed, as was to be expected, the full amount of increase with the true internal resistance, viz., within the liquids of the battery. In table XII, the mean of the first three values of the true internal resistance, in column (R), is 3·66. The same true internal resistance at low intensities, may be calculated either by the formula

$$(R)=\frac{(P_2-P_1)I_1I_2-P_3I_3(I_1-I_2)}{I_3(I_1-I_2)},$$

with the same observations, (Cu) has been calculated, as per page 51; or, the values for (Cu) computed there, and specified in columns 3 and 4, on page 51, may simply be deducted from the corresponding mean values of the whole internal resistance of table

XII. Thus we get (R) at low intensities, equal 20·90−4·66= 16·24; and equal 21·99−4·27=17·72; with a mean of 16·98. From 3·66 to 16·98, the increase is as 1 to 4·64; while the increase of the full internal resistance, the copper wire included, is only from 5·02 to 21·445, or from 1 to 4·27, for the corresponding values of table XII. Here again the influence of the introduction of 100 cm. of copper wire appears as reducing the true amount of increase of resistance, and it seems safe to recognize this increase as residing mainly if not entirely, within the liquids. The contrary result exhibited in columns (Cu), (R) and (*a*), is therefore due exclusively to the method of calculation.

My series of experiments, most of them, show the values for the internal resistance, after the general great increase, to decrease for the lowest intensities. This becomes more visible from a graphical representation of the course of the internal resistance. This circumstance may partly depend on constant faults of the observations of small deflections of the compass needle. But it seems certainly to depend partly on the circuit being formed with copper conductors. The influence of the intensity upon the internal resistance, appears to become constant at low intensities. Any further variation of the internal resistance will then be due to the influence of temperature upon the liquids on one side, and upon the copper conductors on the other side. Now, as the resistance of the copper increases with the temperature, from 3 to 4 times more than the resistance of the liquids decreases, their combined result may produce a reduction of the internal resistance, to some extent, with further decrease of intensity.

On page 388 I ought to have mentioned the so-called "Uebergangswiderstand," or resistance to passage from solids into liquids, as one of those circumstances which may influence, or bring forth the results of my experiments. However, from what I could learn about this kind of resistance, I at first could not make much of it. Fechner represented it as in direct proportion with the intensity of the current (see G. Wiedermann's Galvanismus, vol. i, page 449, which, however, is contradicted by De la Rive's Treatise, vol. ii, page 402). Such relation would not harmonize at all with my experiments. Poggendorff found the reverse to be the case; but the idea of such resistance was generally discountenanced, and the polarization was considered as sufficient to explain the whole matter, in most cases. To be sure, the existence of such resistance in other cases was acknowledged, and Neumann and Wild gave methods to determine it. Experimenting with a Daniell's battery, Neumann found the increase of this peculiar resistance to be in direct proportion with the intensity of the current. But I could not form any idea about the amount of this resistance compared with the common resistance of the liquids, since I had at hand nothing but a meager

report about those experiments. Besides this, the figures given by Neumann were then (1857) not free from doubt as to their being increased on account of a possible neglect of a part of the polarization.

Apart from all these doubts, I have to confess it, the indiscriminate use of the formula E=IR was the chief reason of my neglecting the resistance to passage, "Uebergangswiderstand," since the electro-motive force of the battery seemed to increase in the same ratio as the internal resistance, and did so indeed if calculated from column (*a*), after the common method. Later, guided by the fact of the resistance of the copper wire, if calculated from low intensities, following its own course, and by the evident inconsistency of combining intensities widely differing from each other, I proposed to calculate the electro-motive force not with the direct intensity, but with those intensities every higher resistance is derived from. Taking table XII, as a specimen, there result from the first and last resistances of 14 columns, the following values for the electro-motive force:

(*a*)													
4·37													
4·31	3·86												
4·60		5·66											
			7·37										
				7·05									
					6·96								
						9·66							
							7·82						
								8·30					
									9·03				
										9·21			
											9·38		
												9·92	
													9·69
8·77	8·95	9·16	9·29	9·34	9·41	9·48	9·48	9·53	9·56	9·58	9·63	9·67	9·62

The mean of the first three values of column (*a*) is 4·42; the mean of the last six values is 9·67, the ratio of increase therefore equal 1 to 2·133. I could not venture to determine, without knowing exactly the influence of temperature, whether or not, this increase of electro-motive force is due, partly, or exclusively, to this influence of temperature upon the resistance of the unit of the rheochord, or to a loss of electro-motive force, which I suppose to occur at high intensities. But I expect that a closer investigation of the matter will support my views about this point.

With the foregoing examination of the electro-motive force, I hope again to have thrown some new light upon the reason of differences between the values of the electro-motive force of a battery, as given by different experimenters, or derived from different methods. The variations are here not so great as in case of the specific resistances; the electro-motive force of the Grove battery for instance, varying from 167 (Poggendorff's low-

est figure) to 192 Lenz and Saweljev), when the force of Daniell's battery is taken as 100. The reason for this small amount of variation however seems to be obvious. There are less observations recorded as in the other case, and perhaps mainly such results which were considered as "reliable," thus excluding extreme values which, under certain circumstances are liable to turn up.

If I take from the above table, 9·67 as an approximation to the true electro-motive force of the battery, the internal resistance of the battery, at common temperatures, would result as $\frac{9{\cdot}67}{0{\cdot}8865} = 10{\cdot}9$, and the internal resistance would appear to increase from 10·9 to 21·30, or from 1 to 1·954, and this from some other reason than the influence of temperature upon the measuring rheochord wire. These figures however cannot convey a true idea of the relative importance of the temperature on one side, and of all the other reasons, if there exist more, for the increase of electro-motive force, and internal and external resistance, on the other side, since the simple formula of Ohm does not detail what is constant, and what undergoes variations in different degrees.

What this reason is I am still at a loss to know. I hold that it is not polarization. It seems very probable that the resistance to passage, "Uebergangswiderstand," will furnish the key to the results of my experiments. But it will require other experiments quite differently arranged and detailed to settle this question. I think it will no longer do to use Ohm's simple formula, and to permit the intensity of the current, and the temperature produced by it, to influence the determinations of electro-motive forces and resistances, to an unknown extent, and varying widely according to uncontrolled circumstances.

TABLE VI.

Battery, zinc in diluted sulphuric acid; gas coke in properly acidulated solution of bichromate of potash. Both liquids had been used once before.

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resist.		Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resist.	
0	23°	·4245	....			0	20·9	·3819	....		
2	20·6	·3759	$\frac{15{\cdot}47}{41{\cdot}76}$	28·61		2	19·4	·3521	$\frac{23{\cdot}63}{27{\cdot}29}$	25·46	
0	21·5	·3939	....			0	20·7	·3779	....		
2	19·6	·3561	$\frac{14{\cdot}9}{22{\cdot}39}$	18·65	25·69	2	19·1	·3462	$\frac{21{\cdot}84}{29{\cdot}21}$	25·52	25·00
0	21·2	·3879	....			0	20·3	·3699	....		
2	20·1	·3660	$\frac{33{\cdot}42}{26{\cdot}24}$	29·83		2	18·9	·3424	$\frac{24{\cdot}90}{23{\cdot}14}$	24·02	
0	21·5	·3939	....			0	20·4	·3720	....		
2	19·4	·3521	$\frac{16{\cdot}85}{23{\cdot}63}$	20·24							

TABLE VI (continued).

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resist.		Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resist.	
0	20·4°	·3720	....			0	20·1	·3660			
4	18·6	·3365	37·91 / 42·73	40·32	36·5	4	17·7	·3191	27·21 / 26·10	26·65	28·42
0	20·2	·3680	....			0	20·2	·3680	....		
4	18·2	·3287	33·45 / 31·91	32·68		4	17·8	·3211	27·38 / 33·02	30·20	
0	20·3	·3699	....			0	19·8	·3600	....		
4	18·2	·3287	31·91 / 35·25	33·58							
0	19·8°	·3600	....			0	19·5°	·3541	....		
6	17	·3057	33·78 / 35·00	34·39	33·34	6	16·5	·2962	30·69 / 29·67	30·18	31·08
0	19·7	·3581	....			0	19·6	·3561	....		
6	16·8	·3020	32·30 / 32·30	32·30		6	16·6	·2981	30·84 / 33·12	31·98	
0	19·7	·3581	....			0	19·4	·3521	....		
6	16·3	·2925	26·75 / 28·49	27·62							
0	19°	·3443	....			8	15·6°	·2792	30·64 / 26·43	33·54	31·69
8	15·8	·2830	36·93 / 36·93	36·93	33·44	0	18·8	·3405	....		
0	19	·3443	....			8	15	·2679	29·25 / 28·05	28·65	
8	15·7	·2811	32·42 / 28·86	30·64		0	19	·3443	...		
0	19·4	·3521	....			8	15·3	·2736	30·96 / 34·79	32·87	
8	15·8	·2830	32·76 / 32·76	32·76		0	18·6	·3365	....		
0	19·4	·3521	....								
0	18·6°	·3365	....			0	18·8°	·3405	....		
10	14·4	·2567	32·17 / 29·30	30·73	31·36	10	14·6	·2605	32·56 / 31·09	31·82	31·75
0	19	·3443	....			0	19	·3443	....		
10	14·7	·2623	32·0 / 32·0	32·0		10	14·5	·2586	30·17 / 33·19	31·68	
0	19	·3443	....			0	18·6	·3365	....		
10	14·7	·2623	32·0 / 33·54	32·77							
0	18·6°	·3365	....			0	17·8°	·3211	....		
20	12·1	·2145	35·16 / 36·78	35·97	35·27	20	11·6	·2054	35·50 / 34·38	34·94	34·66
0	18·3	·3308	....			0	18	·3249	....		
20	11·8	·2089	34·27 / 34·87	34·57		20	11·6	·2054	34·38 / 34·38	34·38	
0	18·2	·3287	....			0	18	·3249	....		
20	11·6	·2054	33·32 / 35·50	34·41							

TABLE VI (continued).

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resistance.	
0	18°	·3249	....		
30	10	·1763	35·59 34·23	34·91	37·33
0	18·3	·3308	....		
30	10·3	·1817	39·24 40·25	39·75	
0	18·1	·3268	....		
30	10·1	·1781	35·93 35·48	35·71	

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resistance.	
0	18·2°	·3287	....		
30	9·85	·1736	33 58 35·79	34·68	34·37
0	17·7	·3191	....		
30	9·6	·1727	35·32 33 21	34·26	
0	18·2	·3287	....		

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resistance.	
0	18·2°	·3287	....		
40	8·7	·1520	34·41 35·96	35·18	34·72
0	17·8	·3211	....		
40	8·4	·1477	34·07 34·47	34·27	
0	17·7	·3191	....		
40	8·6	·1513	36·96 37·33	37·15	36·09
0	17·4	·3134	....		
40	8·3	·1459	34·84 35·24	35·04	
0	17·3	·3115	....		

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resistance.	
60	7·4°	·1329	44·64 44·64	44·64	41·37
0	17·3	·3115	....		
60	6·9	·1210	38·11 —	38·11	
0*	16·4	·2943	....		
60	7·0	·1228	42·96 43·42	43·19	
0	16·3	·2925	....		
60	6·8	·1192	41·27 41·27	41·27	39·76
0	16·3	·2925	....		
60	6·5	·1139	38·26 38·26	38·26	
0	16·3	·2925	....		

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resistance.	
0	16·3°	·2925	....		
120	4·3	·0752	41·53 41·19	41·36	41·85
0	16·4	·2943	....		
120	4·4	·0770	42·52 42 15	42·34	
0	16·5	·2962	....		
120	4·3	·0752	40 83 42·29	41·56	

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resistance.	
0	16·1°	·2886	....		
120	4·1	·0716	39·59 39 95	39·77	39·57
0	16	·2867	....		
120	4	·0699	38·69 40·08	39·38	
0	15·6	·2792	....		

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resistance.	
0	15·6°	·2792	....		
200	2·8	·0489	42·47 39·47	40·97	41·54
0	15·8	·2830	....		
200	2·8	·0489	41 78 42·47	42·12	
0	15·6	·2792	....		
200	2·7	·0472	40·69 41·48	41·08	

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resistance.	
0	15·8°	·2830	....		
200	2·7	·0472	40·03 41·69	40·86	40·09
0	15·3	·2736	....		
200	2·6	·0454	39·79 38·84	39·32	
0	15·6	·2792	....		

* This observation was made after the battery having been open for some time.

TABLE VII. *Internal resistance.*

Rheochord.	Tangent.	(a)												(b)								
0	1·9820	....																				
10	1·8008	99·38	....																			
20	1·6689	106·60	116·52	....																		
30	1·5225	9·.41	99·41	84·	....																	
40	1·4455	107·77	112·05	109·41	157·73	....																
50	1·3484	106·41	109·22	106·21	124·9	96·87	....															
60	1·2955	113·23	118·19	118·8	141·2	132·6	194·9	....														
70	1·2442	118·04	124·1	126·5	148·8	145·4	188·8	182·5	....													
80	1·1659	114·29	118·5	119·0	133·5	126·9	141·6	120·0	78·9	....												
90	1·1185	116·58	121·3	122·2	136·0	131·0	144·6	129·6	107·9	156·0	....											
100	1·0767	118·93	123·8	125·4	139·0	135·2	148·1	136·9	122·8	161·4	167·6	....										
110	1·0303	119·08	123·7	125·2	137·4	133·7	144·3	134·2	122·7	147·9	143·6	122·0	....									
120	·9939	120·70	125·5	127·2	139·2	136·1	146·2	137·7	128·5	151·1	149·3	140·1	163·0	....								
130	·9593	121·94	126·8	128·7	140·3	137·5	147·2	139·7	132·0	152·1	151·0	145·1	160·2	157·2	....							
140	·9320	124·27	129·4	131·7	143·6	141·5	151·4	145·1	138·9	159·0	159·9	157·6	174·4	181·1	211·3	....						
150	·8989	124·49	129·5	131·8	143·0	140·9	149·9	144·0	138·2	155·6	155·6	152·8	163·6	163·8	167·6	131·5	....					
160	·8773	127·06	132·5	135·1	146·7	145·2	154·8	149·8	145·2	163·2	164·6	164·0	176·6	181·0	190·7	180·7	256·1	....				
170	·8472	126·91	132·1	134·6	145·5	144·1	153·5	147·8	143·4	159·2	159·8	158·4	167·6	168·8	172·5	159·7	177·7	121·4	....			
180	·8260	128·61	134·0	136·8	147·8	145·0	155·5	151·1	147·2	163·0	164·1	163·5	173·0	175·1	179·8	171·7	189·9	162·0	219·6	....		
190	·8014	128·97	134·3	137·0	147·8	146·6	155·1	150·8	147·1	161·8	162·7	161·9	170·0	171·4	174·5	166·8	178·7	156·7	179·8	145·6	....	
200	·7844	131·0	136·6	139·6	150·6	149·8	158·5	154·8	151·8	166·7	168·2	168·3	177·1	179·5	183·9	178·8	192·5	177·7	204·7	197·1	271·6	
Mean values,		128·51	133·9	136·6	147·7	146·1	155·5	150·5	146·9	162·8	163·9	163·2	172·9	175·2	180·3	171·6	198·9	Mean value of all these figures, 183·6				

TABLE VIII. (R.+Cu.) *Internal resistance, 200 centimeters of copper wire included.*

Rheochord.	Copper wire.	Tangent.	(Cu.) Resist. of the copper.	(R.) True inter. resistance.	(a)														(b)			
0	0	1·9820																				
0	200	·7844			....																	
2	"	·6063	4·13	2·68	6·81	....																
4	"	·4751	3·92	2·43	6·35	5·24	....															
6	"	·4031	3·83	2·51	6·34	5·93	7·20	....														
8*	"	·3585	4·07	2·66	6·73	6·68	8·30	10·08	....													
10*	"	·3310	4·41	2·89	7·30	7·62	9·78	12·36	16·08	....												
12	"	·3042	4·59	3·01	7·60	8·07	10·24	12·45	14·41	12·25	....											
14	"	·2851	4·82	3·17	7·99	8·65	11·00	13·32	15·30	14·84	17·85	....										
16	"	·2614	4·82	3·17	7·99	8·61	10·67	12·44	13·54	12·53	12·43	8·06	....									
18	"	·2493	4·70	3·69	8·39	9·17	11·45	13·45	14·83	14·41	15·24	13·85	25·20	....								
20	"	·2401	5·33	3·49	8·82	9·80	12·35	14·62	16·33	16·41	17·96	18·00	28·62	34·2	....							
30	"	·1911	5·84	3·82	9·66	10·89	13·49	15·63	17·11	17·36	18·41	18·52	22·05	22·77	19·0	....						
40	"	·1575	6·07	3·98	10·05	11·33	13·85	15·80	17·09	17·23	18·06	18·25	20·38	20·61	18·13	16·88	....					
50	"	·1326	6·16	4·02	10·19	11·44	13·81	15·57	16·65	16·73	17·48	17·43	19·00	19·04	17·00	15·33	13·25	....				
60	"	·1158	6·42	4·12	10·54	11·69	14·41	15·76	16·81	16·90	17·50	17·46	19·01	19·03	17·34	16·13	15·54	18·93	....			
70	"	·1033	6·42	4·20	10·62	11·96	14·34	16·05	17·09	17·22	17·82	17·82	19·29	19·34	17·75	17·06	17·17	20·51	22·64	....		
80	"	·0910	6·34	4·16	10·50	11·77	14·00	15·57	16·49	16·54	17·02	16·94	19·35	18·14	16·62	15·46	14·73	15·62	13·38	40·0		
	Mean values,				10·55	11·81	14·25	15·79	16·80	16·89	17·45	17·41	19·22	18·84	17·24	16·22	15·81	18·35				

* These lengths of the wire were hotter than shorter lengths, on account of conduction. 7·5 cm. length was the hottest, being very dark red.

TABLE IX. *Internal resistance.*

Rheochord.	Tangent.																						
0	1·4322	(*a*)																	(*b*)				
6	·4673	2·91																					
8	·4083	3·19	7·86																				
10	·3730	3·52	9·84	13·13																			
12	·3413	3·76	10·27	12·37	11·53																		
14	·3165	3·97	10·80	12·69	12·41	13·52																	
16	·2931	4·12	10·83	12·35	12·01	12·32	11·05																
18	·2772	4·32	11·50	13·14	13·15	13·95	14·21	18·87															
20	·2595	4·43	11·49	12·93	12·86	13·38	13·32	14·89	11·32														
30	·2050	5·01	12·76	14·18	14·40	15·07	15·42	16·58	16·07	17·61													
40	·1687	5·84	13·22	14·53	14·77	15·37	15·68	16·54	16·20	17·16	16·47												
50	·1439	5·59	13·58	14·85	15·12	15·70	16·01	16·48	16·12	16·85	16·18	15·76											
60	·1263	5·80	14·01	15·29	15·60	16·19	16·50	17·31	17·15	17·93	18·14	19·57	24·73										
70	·1124	5·96	14·27	15·55	15·87	16·48	16·84	17·58	17·46	18·20	18·55	19·89	22·98	20·86									
80	·1008	6·06	14·36	15·60	15·92	16·50	16·85	17·55	17·43	18·11	18·37	19·38	21·32	19·06	16·90								
90	·0908	6·09	14·26	15·45	15·74	16·27	16·58	17·21	17·07	17·67	17·70	18·28	19·31	16·73	14·08	10·80							
100	·0827	6·13	14·22	15·36	15·64	16·14	16·42	17·01	16·86	17·42	17·33	17·70	18·34	15·87	13·53	11·38	12·1						
110	·0761	6·17	14·24	15·36	15·63	16·12	16·39	16·96	16·82	17·34	17·23	17·52	18·05	15·80	13·87	12·43	13·54	15·30					
120	·0715	6·31	14·60	15·77	16·09	16·62	16·93	17·55	17·54	18·00	18·20	18·85	19·80	18·28	17·40	17·61	21·14	27·68	45·43				
130	·0664	6·32	14·54	15·69	16·00	16·50	16·79	17·39	17·28	17·82	17·91	18·41	19·16	17·59	16·61	16·51	22·95	22·21	26·91	10·20			
140	·0621	6·35	14·54	15·68	15·97	16·47	16·76	17·33	17·22	17·75	17·80	18·25	18·91	17·38	16·42	16·28	18·19	17·23	23·07	12·13	14·42		
150	·0581	6·34	14·45	15·56	15·83	16·31	16·58	17·12	17·00	17·50	17·46	17·78	18·27	16·67	15·60	15·22	16·60	18·01	19·11	10·09	10·00	5·25	
Mean values,		6.34	14·51	15·64	15·93	16·43	16·71	17·28	17·17	17·69	17·72	18·15	18·78	17·31	16·31	16·00	19·25	19·15	23·03	10·81			
																18·51							

TABLE X. (R+Cu.) *Internal resistance, 25 centimeters of copper wire included.*

Copper wire.	Rheochord.	Tangent.	(Cu.) Resistance of the cop. per wire.	(R.) True inter. resistance.	(a)										(b)									
0	0	1·3223																						
25	0	1·1512																						
25	4*	·5375	·45	3·18	3·53	—																		
25	6	·4519	·50	3·38	3·88	6·56	—																	
25	8	·3992	·55	3·69	4·24	7·54	9·15	—																
25	10	·3615	·59	3·98	4·57	8·32	10·0	11·18	—															
25	12	·3315	·63	4·22	4·85	8·78	10·52	11·58	12·1	—														
25	14	·3063	·66	4·41	5·07	9·24	10·83	11·78	12·19	12·31	—													
25	16	·2863	·69	4·60	5·29	9·67	11·28	12·29	12·84	13·33	14·63	—												
25	18	·2690	·71	4·78	5·49	10·02	11·64	12·66	13·26	13·82	14·84	15·1	—											
25	20	·2534	·73	4·91	5·64	10·30	11·87	12·85	13·44	13·95	14·74	14·81	14·48	—										
25	30	·2017	·82	5·55	6·37	11·61	13·34	14·46	15·24	15·98	16·85	17·38	17·96	19·01	—									
25	40	·1674	·88	5·98	6·86	12·28	14·00	15·11	15·87	16·56	17·33	17·78	18·24	18·93	18·8	—								
25	50	·1434	·92	6·19	7·11	12·73	14·45	15·54	16·3	16·96	17·7	18·12	18·53	19·11	19·48	19·75	—							
25	60	·1244	·94	6·35	7·27	12·86	14·51	15·54	16·23	16·83	17·45	17·81	18·13	18·57	18·28	17·86	15·74	—						
25	70	·1109	·97	6·49	7·46	13·15	14·81	15·85	16·55	17·16	17·78	18·14	18·47	18·91	18·85	18·88	18·25	22·14	—					
25	80	·0996	·98	6·60	7·58	13·29	14·92	15·93	16·62	17·22	17·8	18·14	18·45	18·85	18·77	18·49	18·22	20·32	18·14	—				
25	90	·0919	1·00	6·81	7·81	13·73	15·44	16·52	17·27	17·92	18·57	18·98	19·36	19·83	20·22	20·86	21·38	24·83	26·74	39·35	—			
25	100	·0845	1·00	6·92	7·92	13·91	15·62	16·70	17·45	18·10	18·76	19·17	19·55	20·02	20·47	21·15	21·73	24·71	26·02	31·92	24·2			
Mean values for 50, 60 and 70,					7·28	12·91	14·59	15·64	16·36	16·98	17·64	18·02	18·38	18·86	18·87	18·83	Mean value of all other figures except the three of the two last columns, 21·52							
"	"	"	80, 90 & 100,		7·77	13·64	15·33	16·38	17·11	17·75	18·38	18·76	19·12	19·57	19·82	20·17								
"	"	"	50 to 100,		7·52	13·28	14·96	16·01	16·74	17·36	18·01	18·39	18·75	19·21	19·34	19·50								

* This length of platinum wire was heated dark red.

TABLE XI. (R+Cu.) *Internal resistance, 50 centimeters of copper wire included.*

Copper wire.	Rheochord.	Tangent.	(Cu.) Resistance of the copper wire.	(R.) True inter. resistance.	(a)											(b)				
0	0	1·3062																		
50	0	1·0493																		
50	4*	·5212	·78	3·17	3·95	—														
50	6	·4399	·85	3·48	4·33	6·82	—													
50	8	·3886	·92	3·78	4·70	7·72	9·15	—												
50	10	·3535	1·00	4·08	5·08	8·64	10·36	12·14	—											
50	12	·3247	1·05	4·32	5·37	9·22	10·91	12·32	12·55	—										
50	14	·3008	1·10	4·52	5·62	9·65	11·3	12·56	12·83	13·17	—									
50	16	·2831	1·16	4·77	5·93	10·35	12·2	13·69	14·47	15·83	19·6	—								
50	18	·2670	1·21	4·93	6·14	10·7	12·53	13·95	14·69	15·76	17·6	15·6	—							
50	20	·2496	1·23	5·01	6·24	10·7	12·36	13·54	14·02	14·59	15·25	13·1	10·7	—						
50	30	·1974	1·37	5·58	6·95	11·85	13·53	14·71	15·29	15·91	16·52	15·95	16·03	17·81	—					
50	40	·1664	1·49	6·05	7·54	12·88	14·68	15·96	16·68	17·43	18·17	17·99	18·39	20·0	23·68	—				
50	50	·1419	1·54	6·28	7·82	13·21	14·95	16·11	16·82	17·5	18·15	17·97	18·29	19·52	21·11	17·92	—			
50	60	·1242	1·58	6·47	8·05	13·52	15·24	16·42	17·08	17·73	18·35	18·22	18·53	19·61	20·9	18·86	20·17	—		
50	70	·1110	1·63	6·65	8·28	13·86	15·6	16·79	17·46	18·12	18·75	18·66	19·0	20·04	21·39	20·11	21·84	24·09	—	
50	80	·0996	1·65	6·74	8·39	13·95	15·66	16·81	17·46	18·09	18·67	18·59	18·88	19·84	20·92	19·64	24·09	20·97	17·36	—
50	90	·0908	1·67	6·85	8·52	14·14	15·84	17·0	17·65	18·28	18·86	18·79	19·1	20·02	21·1	20·05	21·07	21·56	19·9	23·18
50	100	·0827	1·68	6·87	8·55	14·1	15·76	16·87	17·48	18·07	18·61	18·52	18·79	19·64	20·47	19·28	19·84	19·71	17·7	17·87	12·1
Mean values for 50, 60 and 70,					8·05	13·53	15·26	16·44	17·12	17·78	18·42	18·28	18·61	19·72	21·13	18·96	Mean value of all other figures, except the last, 20·67.				
"	"	"	80, 90 & 100,		8·49	14·06	15·75	16·89	17·53	18·15	18·71	18·63	18·92	19·83	20·83	19·66					
"	"	"	50 to 100,		8·27	13·79	15·51	16·66	17·32	17·97	18·56	18·46	18·76	19·78	20·98	19·31					

* This length of platinum wire was heated but very dark red.

TABLE XII. (R+Cu.) *Internal resistance, 100 centimeters of copper wire included.*

Copper wire.	Rheochord.	Tangent.	(Cu.) Resistance of the copper wire.	(R.) True inter. resistance.	(a)												(b)					
0	0	1·3240																				
100	0	·8865																				
100	2*	·6307	1·63	3·30	4·93	——																
100	4	·4863	1·61	3·25	4·86	4·12	——															
100	6	·4150	1·75	3·53	5·28	5·69	7·64	——														
100	8	·3730	1·92	3·89	5·81	6·68	9·17	11·76	——													
100	10	·3373	2·03	4·11	6·14	7·19	9·58	11·36	10·9	——												
100	12	·3075	2·10	4·27	6·37	7·51	9·76	11·16	10·77	10·64	——											
100	14	·2891	2·24	4·53	6·77	8·15	10·66	12·37	12·67	13·99	19·42	——										
100	16	·2692	2·30	4·67	6·97	8·42	10·88	12·46	12·74	13·71	16·11	13·05	——									
100	18	·2528	2·37	4·81	7·18	8·70	11·15	12·70	13·03	13·93	15·73	13·86	14·83	——								
100	20	·2394	2·44	4·95	7·39	9·01	11·51	13·09	13·5	14·45	16·12	14·9	16·13	17·73	——							
100	30	·1900	2·70	5·51	8·21	10·07	12·67	14·26	14·84	15·79	17·1	16·67	17·58	18·3	18·46	——						
100	40	·1580	2·86	5·81	8·67	10·7	13·32	14·9	15·51	16·43	17·58	17·33	18·1	18·66	18·82	19·4	——					
100	50	·1363	3·00	6·08	9·08	11·23	13·91	15·51	16·18	17·12	18·25	18·11	18·87	19·44	19·66	20·76	22·81	——				
100	60	·1195	3·08	6·26	9·34	11·55	14·24	15·83	16·51	17·43	18·51	18·41	19·12	19·65	19·86	20·85	22·08	21·13	——			
100	70	·1071	3·18	6·44	9·62	11·91	14·64	16·26	16·97	17·91	18·99	18·95	19·68	20·22	20·47	21·68	23·12	23·35	26·37	——		
100	80	·0954	3·19	6·45	9·64	11·9	14·55	16·09	16·74	17·6	18·58	18·50	19·13	19·57	19·75	20·42	20·95	19·97	19·17	11·54	——	
100	90	·0873	3·25	6·58	9·83	12·14	14·81	16·38	17·05	17·93	18·92	18·87	19·51	19·98	20·17	21·0	21·74	21·26	21·33	18·18	27·77	——
100	100	·0798	3·27	6·62	9·89	12·19	14·83	16·38	17·03	17·89	18·84	18·78	19·39	19·82	20·0	20·69	21·22	20·62	20·40	17·69	22·31	16·4
0	100	·0832																				
Mean values for 50, 60 and 70,					9·35	11·56	14·26	15·87	16·55	17·49	18·58	18·49	19·22	19·77	20·00	21·10	22·67	Mean value of all other figures, except the last one, 20·79.				
"	"	" 80, 90 & 100,			9·79	12·08	14·73	16·28	16·94	17·81	18·78	18·72	19·34	19·79	19·97	20·70	21·30					
"	"	" 50 to 100,			9·57	11·82	14·49	16·07	16·74	17·65	18·68	18·60	19·28	19·78	19·98	20·90	21·99					

* This length of platinum wire did not show any sign of dark red heat.

TABLE XIII. (R+Cu.) *Internal resistance, 150 centimeters of copper wire included.*

Copper wire.	Rheochord.	Tangent.	(Cu.) Resistance of the copper wire.	(R.) True inter resistance																				
					(*a*)														(*b*)					
0	0	1·2877																						
150	0	·7492																						
150	2	·5714	2·68	3·74	6·42	—																		
150	4	·4676	2·78	3·86	6·64	7·0	—																	
150	6	·3972	2·83	3·94	6·77	7·12	7·28	—																
150	8	·3536	2·99	4·16	7·15	7·74	8·4	10·22	—															
150	10	·3247	3·19	4·45	7·64	8·53	9·63	11·91	14·47	—														
150	12	·2974	3·30	4·59	7·89	8·85	9·98	11·88	13·16	11·78	—													
150	14	·2792	3·58	4·84	8·32	9·46	10·82	12·93	14·51	14·54	18·68	—												
150	16	·2606	3·57	4·96	8·53	9·74	11·11	13·07	14·41	14·4	16·32	14·02	—											
150	18	·2462	3·68	5·13	8·81	10·11	11·57	13·56	14·92	15·09	16·85	15·84	18·19	—										
150	20	·2343	3·81	5·29	9·10	10·51	12·07	13·89	15·56	15·91	17·70	17·31	19·63	21·38	—									
150	30	·1860	4·14	5·76	9·90	11·51	13·17	15·13	16·41	16·82	18·05	17·93	18·90	19·07	18·51	—								
150	40	·1551	4·37	6·07	10·44	12·16	13·77	15·78	17·0	17·43	18·51	18·49	19·28	19·45	19·16	20·19	—							
150	50	·1339	4·55	6·33	10·88	12·69	14·46	16·37	17·6	18·07	19·12	19·17	19·93	20·15	20·01	21·4	23·16	—						
150	60	·1174	4·66	6·49	11·15	13·0	14·77	16·66	17·84	18·31	19·30	19·37	20·07	20·28	20·17	21·34	22·28	21·15	—					
150	70	·1051	4·78	6·64	11·42	13·32	15·13	17·03	18·22	18·71	19·69	19·81	20·49	20·73	20·67	21·96	23·06	22·98	25·44	—				
150	80	·0941	4·80	6·69	11·49	13·37	15·14	16·97	18·11	18·56	19·47	19·55	20·17	20·35	20·27	21·41	21·7	20·93	20·77	15·54	—			
150	90	·0866	4·92	6·84	11·76	13·72	15·54	17·42	18·6	19·09	20·04	20·17	20·83	21·07	21·04	22·27	23·21	23·23	24·35	23·62	35·46	—		
150	100	·0787	4·91	6·83	11·74	13·65	15·42	17·22	18·34	18·80	19·66	19·75	20·34	20·53	20·46	21·34	21·81	21·29	21·34	19·43	22·21	9·62		
0	100	·0824																						

Mean value of all other figures except the last one, 22·69.

Mean values for 50, 60 and 70,					11·15	13·0	14·79	16·35	17·89	18·36	19·37	19·45	20·16	20·39	20·28	21·57	22·83							
"	"	"	80, 90 & 100,		11·66	13·58	15·03	17·14	18·35	18·82	19·72	19·82	20·45	20·65	20·59	21·67	22·24							
"	"	"		50 to 100,	11·40	13·29	14·91	16·75	18·12	18·59	19·55	19·64	20·30	20·52	20·43	21·62	22·53							

TABLE XIV. (R+Cu.) *Internal resistance, 200 centimeters of copper wire included.*

Copper wire.	Rheochord.	Tangent.	Resistance of the copper wire. (Cu.)	True inter. resistance. (R.)	(a)																(b)								
200	0	1·2544																											
200	0	·6611	3·59	4·0	7·59																								
200	2	·5233	3·53	3·94	7·47	7·28																							
200	4	·4305	3·74	4·16	7·90	8·19	9·74																						
200	6	·3758	3·74	4·45	8·45	9·10	10·85	12·82																					
200	8	·3397	4·00	4·65	8·65	9·56	11·40	12·77	12·72																				
200	10	·3068	4·17	4·84	9·19	10·13	11·97	13·34	13·08	14·94																			
200	12	·2868	4·35	5·03	9·55	10·61	12·51	13·91	14·47	15·72	16·67																		
200	14	·2681	4·52	5·14	9·75	10·85	12·68	13·97	14·43	15·29	15·52	14·29																	
200	16	·2504	4·61	5·26	9·98	11·12	12·97	14·21	14·69	15·49	15·74	15·20	16·30																
200	18	·2358	4·72	5·36	10·40	11·70	13·71	15·17	15·91	17·06	17·86	18·39	21·30	29·13															
200	20	·2202	4·92	5·48	10·40	11·70	13·71	15·17	15·91	17·06	17·86	18·39	21·30	29·13															
200	30	·1806	5·34	5·94	11·28	12·76	14·79	16·21	16·97	17·95	18·61	19·02	20·22	21·26	19·6														
200	40	·1514	5·62	6·36	11·88	13·47	15·53	16·94	17·73	18·67	19·31	19·73	20·70	21·46	20·48	21·85													
200	50	·1293	5·69	6·34	12·03	13·57	15·51	16·78	17·46	18·24	18·72	18·99	19·67	20·13	19·24	18·93	15·26												
200	60	·1149	5·97	6·65	12·62	14·32	16·39	17·78	18·58	19·47	20·08	20·50	21·31	21·91	21·29	22·47	22·96	36·39											
200	70	·1016	6·01	6·70	12·71	14·38	16·39	17·72	18·46	19·28	19·82	20·17	20·87	21·37	20·77	21·44	21·2	26·39	16·39										
200	80	·0901	5·97	6·65	12·62	14·22	16·11	17·34	17·99	18·71	19·15	19·41	19·97	20·34	19·72	19·78	18·79	20·94	12·66	17·04									
200	90	·0828	6·09	6·79	12·88	14·31	16·48	17·74	18·43	19·18	20·12	19·96	20·56	20·96	20·42	20·8	20·35	22·95	17·38	18·08	33·42								
200	100	·0777	6·30	7·02	13·32	15·09	17·14	18·50	19·28	20·13	20·70	21·00	21·79	22·30	21·9	22·85	23·26	26·93	23·55	27·53	45·82	62·35							
0	100	·0794																											

Mean values for 50, 60 and 70, 12·45 14·09 16·1 17·43 18·17 19·0 19·54 19·83 20·62 21·14 20·43 20·65 19·61 Mean value of all other figures
" " 80, 90 & 100, 12·94 14·54 16·58 17·86 18·57 19·34 19·69 20·15 20·77 21·20 20·68 21·14 20·80 except the last one, 28·44.
" " 50 to 100, 12·69 14·31 16·34 17·64 18·37 19·17 19·76 20·02 20·69 21·17 20·56 21·04 20·30

ART. VIII.—*On Colorado Meteorites—Russel Gulch Meteoric Iron, and Bear Creek Meteoric Iron;* by Prof. J. LAWRENCE SMITH, Louisville, Ky.

THE first of these irons I described in the September number of this Journal, calling it the "Colorado meteorite." Owing to the discovery of another in the same territory (specimens of which have been in my possession for some little time), it will be proper to designate the first mass as the "Russel Gulch" iron and the other as the "Bear Creek" iron. Of this last there are two short notices in the November number of this Journal, pages 260 and 286, the specimen of it in my possession has enabled me to make a thorough examination of the constituents. The piece I have has a portion of the exterior attached.

As has already been stated by Prof. Shepard, it is coarsely crystalline, and laminated from the effects of decomposition between the crystals; the surface contains considerable pyrites, although Prof. Shepard did not discover any in his specimen. I was enabled to separate and analyze magnetic pyrites, schreibersite and nickeliferous iron. Of the magnetic pyrites sufficient was separated to make a quantitative determination which was as follows:

Sulphur,	35·08
Iron,	61·82
Nickel,	·41
Insoluble residue,	1·81
	99·12

The schreibersite was not obtained in sufficient quantity for a complete analysis; about 50 milligrams of the pure mineral gave all the constituents usually found in this interesting mineral.

The nickeliferous iron, constituting of course the great bulk of of the mass, was composed as follows:

Iron,	83·89
Nickel,	14·06
Cobalt,	·83
Copper,	minute quantity
Phosphorus,	·21
	98·99

The laminæ of iron are often very brilliant, having the luster of silver and caused me to suspect more nickel than was found. It was supposed that in the decomposition of the crystals the iron would disappear more rapidly than the nickel, and that by a process of cementation, the nickel would accumulate in the

laminæ; but from careful examination of the process of decomposition, there is no doubt that the interior of the mass will not differ materially in its composition from the analysis already given of the nickeliferous iron. Besides the minerals already mentioned, and which properly belong to the original mass, there is much oxyd of iron, containing some nickel arising from the decomposition of the surface.

ART. IX.—*On a new locality of Tetrahedrite, Tennantite, and Nacrite, with some account of the Kellogg Mines of Arkansas;* by Prof. J. LAWRENCE SMITH.

A SHORT time since Prof. E. T. Cox of Indiana sent to me an antimonial copper ore containing silver, one fragment being the termination of a crystal having a number of small but beautiful faces, another was a minute crystal of a different form; in the hands of Prof. Cox a blowpipe analysis had given about five per cent of silver in some of the mineral.

The crystalline fragments were first examined and they enabled me clearly to trace out tetrahedrite in one and tennantite in the other. The faces on the tetrahedrite were small but beautiful and very numerous; from the number on the fragment examined there would not have been less than from 60 to 70 had the crystal been perfect: it corresponds very nearly to the cyrstal figured in Dufrenoy's Mineralogy, plate 124, fig. 441, which he speaks of as coming from Moschellandsberg, a locality that I am not able to discover. Good measurements were made on a few of the faces.

P on P 70°; P on b^3 159° 30′; P on a^2 144° 30′

Specific gravity of different specimens varied from 4·78 to 5·08; the latter was the sp. grav. of the above crystal. The analysis of two specimens, No. 2 being a part of the crystal, gave

	1.	2.
Antimony, - -	26·50	27·01
Sulphur, - -	26·71	25·32
Copper, - - -	36·40	33·20
Iron, - - -	1·89	·82
Zinc, - - -	4·20	6.10
Silver, - - -	2·30	4·97
Arsenic, - - -	1·02	·61
	99 02	98 03

The quantity of No. 2 analyzed did not exceed 300 milligrams.

There are two minerals consisting of minute micaceous scales on the quartz containing this gray copper. One of them I could not obtain in sufficient quantity for examination; from an imperfect examination I conclude that it is muscovite; the other mineral, a soft unctuous talc-like mineral, is nacrite, composed as follows:

Silica, - - - - - - -	65·02
Alumina, - - - - - - -	26·11
Oxyd of iron, - - - - - -	2·20
Manganese, - - - - - -	*trace*
Potash and soda, - - - - -	1·18
Water, - - - - - - -	4·98
	99·49

These minerals came from an exceedingly interesting mine in Arkansas that is as yet almost unexplored; I have obtained a full description of it from Prof. Cox and I think it would be well to give it here, for besides being likely to prove of considerable commercial value when properly explored, there will doubtless be found many interesting mineral species there.

The Kellogg mines are situated 10 miles north of the city of Little Rock in Pulaski Co., Ark. The country in the vicinity is rolling, the highest hills are about 270 feet above the water level of the neighboring streams. The surface rocks are thick and thin beds of sandstone alternating with shales occupying the base of the coal measures. The rocks are but little disturbed and are for the most part horizontal. There are no metamorphic rocks showing themselves at the surface nearer than Little Rock on the south side of the Arkansas river. Innumerable veins of milky quartz are seen traversing the sandstones and shales.

About seventeen years ago lead ore was discovered at these mines by Mr. Kellogg, companies were organized and mining operations carried on extensively for about one year, when the flattering accounts of the gold discoveries in California caused the miners to leave, and the work which had been badly conducted was abandoned. Many tons of the ore which is an argentiferous galena (containing 60 to 200 ounces of silver to the ton) were extracted from the mine and finally the greater part was shipped to England and sold at a good price. A smelting furnace has been erected on the grounds, but for lack of skill, the proprietor never succeeded in working the ore profitably, consequently the impression was produced that the ore could not be smelted, but there is no good reason for such an opinion.

Since the mines have been abandoned, the old shafts, ranging in depth from fifteen to seventy feet, are all filled in, and the country has become covered with a dense undergrowth of brush

and briars. About one year ago Prof. Cox revisited these mines for a company who had in view to lease or purchase them; it was during this visit that the gray copper above referred to was discovered. This ore has previously escaped the observation of others who had explored these mines. It is impossible at present to see the ore in place, and those who previously worked the mine give conflicting statements as to the manner in which the ore is found.

The vein-rock and associated minerals with the galena are white quartz, spathic iron, zinc blende, copper pyrites, gray copper, tennantite and nacrite.

The mines are now in the hands of a new company, and the latest information from their operations are, that matters look well; the vein now being worked is nearly three feet wide, principally lead ore, the balance being zinc blende; twenty hands are at work, and the shaft is down forty-five feet. My opinion is, that in time this mine will become of considerable importance, and lead to further developments of argentiferous galena in that region.

ART. X.—*On recent Soundings in the Gulf Stream.* — Abstract of a paper read before the National Academy of Sciences; by HENRY MITCHELL, Assistant U. S. Coast Survey.

EARLY in the spring of the present year an application was made to the Coast Survey by the International Ocean Telegraph Company for information relative to the form and character of the bottom of the Straits of Florida between Key West and Havana along the proposed track of the submarine telegraph cable which is to connect the United States with the West India Islands. It was clearly the province of the Coast Survey to supply information of this sort, and a special survey was therefore ordered under instructions from Mr. J. E. Hilgard who, during the illness of Prof. Bache, conducts the work of this bureau. These instructions were carried out carefully and under favoring circumstances, so that the results are entitled to confidence.

The distance from Sand Key, on the extreme southern point of the Florida reef to El Moro rock at the entrance to Havana, is but a trifle over 82 miles. To lay a cable over this short distance would seem to be an easy task and one that should long since have been executed. In fact, however, the locality offers a new problem to the engineer, viz: *to lay a cable nearly at right angles to a strong stream, or system of streams, flowing through a rocky pass of great depth.* The new survey, if it does not, as is hoped, supply the elements for the solution of this problem, at

least develops and gauges the difficulties of the task, and incidentally adds a few items of interest to physical inquiry.

The line of maximum depression was struck at a point 24 miles north of the Moro, and followed some distance to the northeast with depths of 853, 845 and 794 fathoms. The direction of this line does not correspond to that of the Gulf Stream in this neighborhood; but a glance at the map will show that a S.W. course would be a natural one for the *Polar Current*, as it is called, which runs near the bottom.

The numerous soundings of this survey make it possible to develop a profile of section from Sand Key to the Moro, and the subjoined table gives the numerical data for such a profile.

Section of Soundings across the Straits of Florida, from Sand Key to El Moro.

Points on profile.		Distances from Sand Key.	Distances from El Moro.	Depths. By Indicator.	Depths. By outrun of line.	Nature of the reel.	Kind of bottom	Remarks.
Northern approach to channel.	A	2¼	79¼		65		rock.	Coral strewn over with shells.
	B	7½ to 8½	74¼	111	125	5	"	Specimen of coral debris obtained.
	C	11	71¼	129	132	1	"	
	D	14¼	67¾	2~9	309	2	"	Specimen of coral debris.
	E	18¼	64	369	397	1	mud.	Specimen of gray mud.
	F	24¼	58	432	466	1	"	Specimen of mud nearly white.
	G	29½	53½	504	553	2	"	Specimen nearly white with dashes of red.
	H	34	48¼	687	No indication of depth by the outrun of line.	1	"	Specimen of stiff mud, nearly white.
	I	38	44¼	794		1	"	Specimen gray and granular mud.
Southern approach to channel.	i	45½	36¾	845		1	"	Specimen nearly white with red tinge.
	h	51¼	31	842		3	"	Specimen same as above.
	g	55¾	26½	813		2	"	Specimen same as above.
	f	60	22¼	455		2	"	Specimen of mud with drab color.
	e	61½	20¾	380		1	"	No specimen—some doubt of cast.
	d	67½	15	710		1	har.l.	
	c	73¼	9	748		1	mud.	
	b	7~½	3¼	583	620	1	sand.	Sand or mud of reddish brown hue.
	a	80½	1¼	243	244	1	rock.	A small shell obtained.

In this profile, which is, strictly speaking, that of a diagonal section, the point of maximum depression is found 37 miles from the Moro, and is 843 fathoms. The approaches to the great valley from the two coasts are dissimilar in general features. From the northward the bottom falls away in *terraces* whose intervening slopes are nowhere abrupt; while from the southward an irregular and hilly approach is found with indications of abrupt if not precipitous changes of elevation. Above the terraces of the north shore the sea lies almost motionless, while among the cañons of the southern half of the Straits flow the Gulf Stream and its counter currents.

These natural distinctions authorize us in taking up separately the descriptions of these approaches, and we shall proceed to do so briefly, commencing at Sand Key and following the profile southward from A to I: then commencing at the Moro and following northward from *a* to *i* (see table).

Northern Approach.—Leaving Sand Key, the water deepens rapidly to 13 fathoms, then shoals again to 7 fathoms upon a coast bar or ridge parallel to the reef, and scarcely ¾ths of a mile distant from it. Seen from the deck of a ship upon a fine day this bar is marked by a narrow belt of pale blue-green water in beautiful contrast with the dark blue-black of the ocean. The bottom can be seen on crossing it and appears to be a pure white rock *in situ*, strewn sparsely over with fragments of the weathered and brown reef rock. Two miles farther out carries us to the point A, where our table for the profile commences with sixty five fathoms of water on a slope of one foot in thirty seven. The next points B and C lie upon a nearly level plain which terminates about twelve miles from the reef in a slope of one foot to twenty-two. Upon this terrace numerous soundings were made covering about eight miles of longitude, which show that the formation belongs to the reef system and lies parallel to it. Chips of white coral rock were brought up in one of the casts—in all of them the hard bottom was felt by the hand. At what appears to be the foot of the fore slope of this terrace (point E) the bottom is found to be soft mud, and a specimen procured proved to be of a grey color quite in contrast both as regards color and consistency, with that obtained above or beyond. It differed from the white muds beyond, of which we shall hereafter speak, in possessing a granular character and retaining the same when dry. It is conceived that this terrace was once a dry reef covered over like Sand Key with dark fragments of agglomerated reef rock, and that a subsequent submergence has caused all this loose and weathered material to be swept down to the foot of the fore slope.

Between D and E, in about 300 fathoms, the *swept* portion of the Florida Reef, if not also the *base* of the formation, is passed. At F, G and H the bottom is of nearly white mud, with dashes of red at the last named point. These muds were found to *set* on drying. The mud with dashes of red is supposed to be the debris of a kind of coral, quite common upon the reef, which is spotted as if with drops of blood. These three stations seem to comprise another grand terrace, because at the 500 fathoms curve there seems to be a considerable belt where a difference of a mile in latitude or longitude scarcely altered the soundings. If this is so, we must suppose that we are not yet beyond the reef and that the rock still underlies the material which the specimen cup procures. *At the foot of the fore slope of this second terrace* (I)

in 794 *fathoms, the mud is again grey* and *granular* while the next station beyond is of the ordinary white tinged with red.

Do these features belong to the history of the Gulf Stream or to the geology of the coral reef? As these slopes and terraces are now scarcely traversed by the streams, we are inclined to regard them as exhibiting the order in which, through successive ages, the reef has alternately subsided and stood still. As far as the swept portion of the reef apron extends, we see no indications of any caving down of the structure; and in the neighborhood of the second terrace the presence of mud forbids the supposition of long continued abrasion.

Southern Approach.—The Moro Rock is nearly perpendicular at the water line but retreats at points higher up. Its northwest profile is convex with a mean dip of 45° from the castle wall to the sea. Leaving this rock and advancing 1¾ miles northward, the bottom declines 1 foot in 7 to point *a*, where the depth is 243 fathoms and the bottom, *rock*. From *a* to *b* the depth increases very rapidly, 1 foot in 6, and the foot of the Moro Rock is passed. The bottom at *b* is a reddish brown mud which becomes in part granular on drying—*in many respects it resembles the specimens from the foot of the fore slope of the coral terrace on the north bank of the straits.* It is no doubt weathered debris swept down from the Moro.

The dip of the rocky part of this space between *a* and *b* is unquestionably much more precipitious than the mean we have stated, because 1 foot in 6 is altogether too great an inclination for the material found at *b*.

Beyond *b* the slope is gradual, 1 foot in 32, and terminates at *c* in the nearly horizontal bed of a depression which we shall call the Moro Channel. Here at *c* the depth is 748 fathoms. Six miles farther carries us across the Moro Channel and we find the depth a trifle more shallow, 710 fathoms, at *d*.

At *e* and *f* we find ourselves near the summit of a submarine mountain whose height above the bed of the Straits is about twenty four hundred feet. This mountain, lying but a few miles to the northward of the axis of the Gulf Stream, may be claimed as a point of decided interest in this survey. It is scarcely twenty one miles from the shore of Cuba whose hills are in full view if the weather is fine. Six casts were made upon its summit under the greatest difficulties, owing to the current. Only three of these proved successful and but one yielded a specimen of bottom. The depth on the summit was found to be about 400 fathoms. On looking over the work of former years we find that Capt. B. F. Sands in 1858 made deep sea soundings in this locality, and that he struck one sounding of 320 fathoms on the same parallel, but some twelve miles to the westward. He procured a specimen and observed the temperature to be 60°

which is the usual amount for this depth in the Straits of Florida. The Polar current which underlies the stream, following the line of maximum depression, has a temperature of less than 45°. At first thought, it might be supposed that an obstacle in the track of the stream would cause an ascension of the Polar current, but when we consider that this Stream Bank has not the nature of a bar, and that the deep channel way beyond is ample, there would seem to be no reason for an ascension of the cold waters in this neighborhood.

Several other casts, not referred to in our table, because too far to the eastwasd of the section line, furnish some clue as to the form of the Stream Bank. It appears to be triangular in its general figure, presenting at its west angle a bold prow to the stream. As the current is here flowing with an accelerating velocity, a *deposit* is impossible. This bank, it appears to us, must have, like the adjacent reef, a firm constitution. It is an interesting question whether it belongs to the mountain system of Cuba (as its line of least water running E. and S. E. might seem to indicate), or whether it is an ancient reef now wearing and crumbling away. The least depth is about that of the foot of the *swept* portion of the reef apron on the north side of the Straits —it may indicate the true depth of the Gulf Stream itself, and if so, its summit is not now abraded, while its base must be wearing away under the action of the Polar current. A bank so situated must have precipitious slopes.

Observations upon the trend of the lead line, on hauling in, furnish indications that the thickness of the upper moving stratum, i. e., the depth of the Gulf Stream, is scarcely more than one third of the maximum depth of the channel. This stream seems to be an *overflowing* of water, not a profound movement. In the exchange between the Gulf of Mexico and the Atlantic, the office of the Gulf Stream appears to be the *restoration of surface level*, while the office of the counter stream, ("Polar current") below, is the *restoration of equilibrium thus disturbed*, between waters of different specific weights or densities. To illustrate this view of compensating currents, we may be suffered to recall an instance from our experience in observations at the mouth of Hudson River. In the dry season (July) the surface *outflow* (brackish) through the Narrows of New York harbor, occupies nine out of the twelve tidal hours, while in the lowest water stratum the case is more than reversed, the *inflow* (salt) predominates to that extent, that as a general thing it is *continual* along the bottom, although not *constant* in velocity. The same conditions, with variable proportions, were followed some distance up the river. On running a line of levels from New York city to Albany it was found that the bed of the Hudson lies below the *mean level* of the sea for over a hundred miles; but that the sur-

face of the fresh water, even in the dry season, is above this level—not so much above, however, as to *equalize the difference of specific weight between it and the sea water*, so that the latter, during the summer months, flows in along the bed of the stream, while the former *overflows* into the ocean.

In the recent survey, observations upon surface densities were carried over several hundred miles. These show decided contrasts between the ocean and the stream, but no greater than the differences of temperature might lead us to expect.

The Gulf Stream is essentially confined to the southern half of the Strait in the portion crossed by this survey, but no westwardly drift along the north shore was observed except at one time a feeble flood tidal current setting close along the reef. It is not impossible that the widths of the Gulf Stream vary, as its velocities are known to do, and both of these may in many cases depend upon long continued gales of wind. During the period of the recent survey, however, the weather was exceedingly calm in the Gulf, and as far as learned, generally quiet at sea, yet the velocities of the stream altered in a marked manner, and so much so that the changes became a matter of comment among pilots and ship masters arriving at Havana. It would be exceedingly interesting and practically useful to ascertain from systematic inquiry the order of these variations. We would suggest as a reasonable hypothesis that these variations follow those changes of *mean-sea-level* which depend upon the declinations of the sun and moon—more especially the latter. There are no two seas upon the earth whose tidal phenomena differ more essentially than those of the Gulf of Mexico and the Atlantic Ocean; and it is a matter of certainty that the elevations of these two bodies of water are not affected in the same manner and degree by the half-monthly changes of the moon's declination. Professor Bache's paper on the "Tides of Key West," published in the Coast Survey Report of 1853 shows that the *mean level* of this station is one foot higher when the moon is in the equator than when she is at her greatest declination. In the North Atlantic the order is the reverse of this; the mean level is there about three inches higher at the maximum than at the zero declination.* Small as these relative changes of elevation may seem they must bear a large proportion to the total head of the Gulf Stream which suffers exceedingly little resistance in its course.

* From computations of the Coast Survey, and from Phil. Trans. R. S., 1839.

ART. XI.—*Observations upon the Glacial Drift beneath the bed of Lake Michigan, as seen in the Chicago Tunnel;* by E. ANDREWS, A.M., M.D., Prof. of Surgery in Chicago Medical College.

IN the November number of this Journal there is an article from E. W. Hilgard, State Geologist of Mississippi, which contains serious errors respecting the Drift formation in Illinois. The mistakes occurred, doubtless, because the distinguished author had not an opportunity for personal observation here, and was obliged to rely on the information of others less competent than himself.

He remarks that the erratic blocks are nearly all well water-worn, and that the drift "is more or less irregularly, but distinctly, *stratified*," and that "*no glacier scorings* are mentioned either on the pebbles or on the adjacent rocks."

The truth is this. The drift of Illinois, Indiana, Michigan and Wisconsin consists of two distinct formations, one above the other. The lower is the well known "glacial drift" of authors. It is a heterogeneous mass, full of boulders and pebbles, which are only imperfectly rounded and sometimes quite sharp at the edges. Vast multitudes of the larger blocks are scratched and polished on one side by unmistakable glacier action. In a large part of the formation it is extremely difficult to discover any traces of stratification, though it can be noticed by great care.

The second formation always overlies the former, and consists of sand and gravel distinctly stratified, and filled with well rounded and water-worn pebbles. The two deposits are so unlike each other that there is no possibility of confounding them. Their relation to each other is best shown in the numerous railroad cuts which traverse them. It is there seen that at a distance from the valleys of streams, the old glacial drift usually comes to the surface, and often rises into considerable eminences. In Illinois, at least, the closest scrutiny generally fails to discover in it any stratification. As we approach the streams, however, the glacial drift sinks out of sight, and is overlaid by perfectly well stratified sand and gravel. The latter exists in enormous quantities, sometimes bordering the valley miles in width, and by its thick masses fully maintains the general height of the country. At the border of the valleys of the streams the sand and gravel suddenly cease, terminating in an abrupt descent; or perhaps the lower strata may continue beneath the alluvium of the bottom lands.

The Chicago tunnel is excavated for two miles in the glacial drift beneath the bed of Lake Michigan. It has been closely watched by a committee of the Chicago Academy of Sciences, as well as by Mr. Chesborough the city engineer, Mr. Krœshell the

inspector, and Mr. Gowan the contractor. From my own personal observation, and from those of the above-mentioned gentlemen, I derive the following facts. The tunnel is to supply the city with fresh water drawn from the lake at a distance of two miles from the shore. For this purpose a coffer dam was erected in the lake, two miles from the land, and within it a shaft was excavated in the clay to the depth of about seventy-five feet below the surface of the water. A similar shaft was sunk at the shore end, and from the bottoms the workmen drifted horizontally until they met beneath the lake.

The shaft at the shore end descended first through beach sand and then through tough clay, mostly free from boulders, and apparently a deposit from the lake. At the depth of about sixty-two feet the workmen came suddenly upon the hard glacial drift, containing glacier-scratched boulders, and in every way very different from the clay above it. The material appeared to be a soft comminuted shale reduced to a clay by the same means which transported it from its original strata. Every cubic yard of it contained millions of broken and scarcely rounded little fragments of the shale. These were accompanied with larger blocks of it, mixed with glacier-scratched boulders of limestone, sandstone, granite, syenite, and every other kind of rock which exists in the regions north of us. In this and similar material the whole of the rest of the shaft and the entire two miles of the horizontal part of the tunnel was excavated. Some extremely interesting facts were observed. For instance, this hard clay showed no trace of stratification when any particular part of it was inspected, yet it was so intercalated with other beds as to clearly prove its right to be called a stratum. After sinking eleven feet through it the workmen came to a thin bed of clay free from boulders, and beneath that to a stratum of sand, six inches in thickness, with another layer of hard clay beneath that. This stratum of sand was traced horizontally for over a thousand feet, when it ascended and disappeared through the roof of the excavation. Several hundred feet farther on another thin stratum of sand was struck whose upper surface clearly showed *ripple marks*. It was singular to observe that the clay resting upon it preserved a perfect cast of the ripple marks after the sand was removed from beneath it. This stratum extended only about fifty feet, when it thinned out and disappeared. About six thousand feet from the shore a stratum of softer clay entered the roof of the excavation, resting upon the hardpan beneath. Both formations contained boulders. These two strata followed so exactly the level of the tunnel that their junction was traced for four thousand feet farther, and was only lost at the outer extremity of the work, two miles from shore. It would seem therefore that in spite of the absence of minute

layers in the clay, the stratified character of the whole mass is clearly made out.

The most surprising phenomenon discovered, was the existence all through the glacial drift, of numerous isolated "pockets" or cavities filled with stratified gravel. These "pockets," as the workmen called them, lay in all imaginable positions, sometimes with their strata set up at high angles. They were generally from a few inches to a few feet in diameter, and terminated abruptly on all sides in the solid impermeable clay. The gravel was water-worn, and often so clean that it would scarcely soil a handkerchief. Its interstices commonly contained a few gallons of water at the lower part, and some air or gas at the upper. The gas in many instances was inflammable, and was doubtless derived from the numerous boulders of highly bituminous limestone found in the clay. That the pockets were perfectly isolated is shown by the fact that though nearly eighty feet beneath the surface of the lake, they scarcely leaked a drop of water after they were once emptied. The existence of these masses of gravel is very surprising. The cavities, when emptied, looked exactly in many instances like the casts of rounded boulders. I can only account for them by the theory that they were deposited as frozen masses of gravel, and thawed after they were well imbedded in the clay, leaving their strata in whatever position they happened to be put while frozen.

After getting beneath the deposits made by the lake itself, the excavations furnished not the slightest traces of any organic remains.

Along the west shore of Lake Michigan, for a distance of over a hundred miles north of this place, the glacial drift rises some eighty feet above the water in precipitous bluffs. In many places the bluffs are eroded by the waves, and show fine sections. To one standing close by it is often extremely difficult to notice any stratification, but to an observer stationed in a boat a hundred yards distant, dim but evident traces of a horizontal arrangement appear. The strata are best seen by noting the level bands where the springs ooze out.

The more recent formation may frequently be noticed as a well stratified deposit filling the hollows or valleys of the older drift, and rising to nearly the same height above the lake. It perhaps belongs to the Champlain epoch. It is greatly to be desired that some geologist should thoroughly examine the recent geology around Lake Michigan, as there are problems of great interest to be solved in connection with it; but as yet it is an unexplored field.

Chicago, Nov. 26, 1866.

ART. XII.—*Shooting Stars in November*, 1866; by H. A. NEWTON.

THE brilliant exhibition of the November meteors witnessed in Europe on the 14th of that month is a confirmation (if such confirmation was needed) of the astronomical character of these bodies, and of the thirty-three-year cycle. The European observations are evidently those which will throw most light upon their cosmical relations. Yet those made in this country on the nights of Nov. 12th–13th and 13th–14th must have decided value. The radiant point in Leo rises above our horizon about 11 o'clock P. M., which corresponds with 4^h A. M. Greenwich time. Our observations then from midnight onward on the morning of the 14th may be regarded as a continuation of those which in England were interrupted by the approach of daylight. They serve to give the law of decrease in density of the meteoroids as we leave the group. On the other hand, during the former night the earth was approaching the group, being at dawn only fifteen hours distant from its center.

1. *At New Haven.*—On the two nights 10th–12th of November the sky was entirely overcast; so also on the nights 14th–16th. On the night of Nov. 12th–13th we commenced counting the shooting stars ten minutes after 11 o'clock. There were fifteen or more in the party, principally students in the College. It was intended that at least twelve persons should be continually looking for the meteors. This number was maintained throughout the watch on this and the following nights, except for a very short period when only eight or ten were present. During part of the time, on the first night particularly, there were, besides the twelve, from two to five others assisting in counting. Two of us gave our attention to the location of the paths of particular meteors, remarkable for size, color, trains, &c., and to other objects aside from the counting.

We watched from the top of the tower of Graduates' Hall, from which there is an unobstructed view of the heavens. To nine persons were assigned particular portions of the sky around the horizon, and three looked toward the zenith. The meteors were counted aloud to prevent duplication. The total number seen by the party in each quarter-hour was thus obtained. It was also important to learn how many meteors each observer saw. To prevent the confusion that would result from counting in a double series, I gave to each person a card with directions to keep a tally upon it of those seen by himself. A few of these tallies were afterwards found to be imperfect, but the residue enable us to compare our numbers with those seen elsewhere by fewer observers.

The first party continued the watch until $1^h\ 40^m$ A. M., counting in these two and a half hours 236 meteors, as follows:

Time.	Duration.	No. seen.	No. per hour.
$11^h\ 10^m$ to $11^h\ 30^m$	20^m	37	
30 " 45	15	27	
45 " 12 0	15	26	108
12 0 " 15	15	22	
15 " 30	15	17	
30 " 45	15	21	
45 " 1 0	15	21	81
1 0 " 15	15	25	
15 " 30	15	20	
30 " 40	10	20	97
Total in $2^h\ 30^m$		236	94 hour. av.

The meteors were generally small and very few of them were from Leo. Few left trains. During these $2\frac{1}{2}$ hours nine of the party saw severally 34, 10, 41, 26, 40, 62, 22, 62 and 68. This gives an average of $40\frac{1}{2}$ to each observer, or 16 per hour. The proportion of the mean for single observers to the whole number seen is 17 per cent.

The large variation in the numbers seen (from 10 to 68) is due to a variety of causes. The three who looked to the zenith saw much the larger numbers. Some of the others may have looked too low down in the horizon, or there may have been a slight haze in the direction toward which they were looking. Besides all this, there is undoubtedly a personal difference depending on closeness of attention and sharpness of eyes.

At $2^h\ 40^m$, after an interval of one hour, a new party began to count, and the following was the result:

Time.	Duration.	No. seen.	Hourly No.
From $2^h\ 40^m$ to $2^h\ 45^m$	in 5^m	15	
45 " 3 0	15	44	177
3 0 " 15	15	38	
15 " 30	15	37	
30 " 45	15	38	
45 " 4 0	15	27	140
4 0 " 15	15	38	
15 " 30	15	44	
30 " 45	15	43	
45 " 5 0	15	44	169
5 0 " 15	15	54	
15 " 30	15	36	180
Total in $2^h\ 50^m$		458	162 hourly av.

The following are the reports of the numbers seen by individual observers. Those looking the whole time saw 56, 41, 100, and 55; one from 3^h onwards saw 26, one from $3^h\ 15^m$ saw 49,

one ending at $4^h\ 10^m$ saw 32, and one ending at $4^h\ 30^m$ saw 23. This gives an average hourly number of about $19\frac{1}{2}$ for each observer, which is 12 per cent of all seen.

By 3^h A. M. the proportion of conformable meteors had considerably increased, so that they were then estimated to be at least one-fourth of the whole number visible. At 5 o'clock the proportion, though greater, was still less than one-half. During the quarter-hour $5^h\ 15^m$–$5^h\ 30^m$ the increasing light of the dawn in the east was interfering very considerably with the numbers visible.

The sky was beautifully clear throughout the night. The center of the radiant of the conformable flights seemed to be about R. A. 147° 30′, Dec. +23° 15′. It was not very easy to determine its shape and dimensions owing to the small number of flights near the radiant. The zodiacal light was remarkably fine in the east.

On the night of Nov. 13th–14th a new relay of observers began to count at 11 o'clock. They were relieved by a fourth party about 2 o'clock A. M. The arrangements were similar to those of the previous night. The following are the results for the successive quarter hours.

11^h–12^h.	12^h–1^h.	1^h–2^h.	2^h–3^h.	3^h–4^h.
22	37	47	33	65
29	43	37	36	36
35	56	50	55	56
36	61	37	55	55
122	197	171	179	212

At 4 o'clock it was decided to break up. A desultory counting gave 20 during the next ten minutes, or 901 in all. Between $1^h\ 15^m$ and $2^h\ 30^m$ the number of observers was not quite as large as usual, and the attention was somewhat broken by the changing of the party. Throughout this time and the hour following the clouds interfered to an appreciable extent.

A considerable portion of the meteors were much more brilliant than those of the previous night; also a much larger proportion proceeded from the Leo radiant. These were brighter than the others. At a quarter past twelve o'clock it was estimated that about three-fifths of all were conformable. During the next hour there was an evident increase in this ratio.

During the first three hours four persons saw severally 116, 98, 82, and 96; one saw in $3\frac{1}{2}$ hours 99. This gives a mean of 32 per hour for each observer, which is 20 per cent of the number seen by the whole party. From half past two o'clock onward the mean hourly number for one person, as deduced from the reports of ten of the party, was about 38, that is, about 18 per cent of the whole.

If we compare the observations of the two nights, we see that the greater brilliancy of the meteors on the second night made the proportion seen by single observers to be greater. At the same time there was a much greater uniformity in the tallies reported. This is reasonable, for when the meteors are faint we may rightly expect a large *personal equation*. The average number of observers for the two nights was probably about fourteen. The mean of the proportions seen by single observers for the two portions of the two nights was about 17 per cent. Hence we may say that with such observers, such meteors, and such modes of observing, as we had on these two nights, fourteen persons will see about six times as many as one person. I think it probable that even so large a party loses a third, or more than a third, of the meteors that could be seen by an indefinite number of observers, especially when the flights are in general faint.

While the general position of the radiant on the second night would seem to be the same as that given on the first night, some stars moved from points nearer γ Leonis. Several paths produced backward would cut the line joining γ and ε Leonis within two or three degrees of the former star. I saw, however, no path that could not be referred to a radiant area of narrow breadth in latitude. In longitude its length would have to be three or four degrees, unless we admit, as Prof. Twining supposes, that there is a motion of the radiant. Prof. Hewitt of Olivet, Mich., gives a number of paths for the first night that seem to proceed from a point nearer γ than ε.

2. *At New Haven.*—Upon the roof of Sheffield Hall a party of about ten students, under the direction of Prof. Lyman, counted 603 meteors in five hours, from 12 o'clock onward, on the morning of the 13th of November. The following is the result of their observations for the successive quarter hours.

12h–1h.	1h–2h.	2h–3h.	3h–4h.	4h–5h.
24	25	38	43	27
21	31	22	39	38
17	..	30	35	34
21	47 for $\frac{1}{2}$h	39	38	34
83	103	129	155	133

On the next night a similar party in the same place counted 492 meteors between eleven and two o'clock, omitting the quarter hour between $11^h\ 15^m$ and $11^h\ 30^m$. This is a mean of 179 per hour. The following table gives the results.

	11h–12h.	12h–1h.	1h–2h.
	19	48	42
	..	48	53
	31	56	52
	38	50	55
Hourly mean	117	202	202

These results agree as well perhaps as could be expected with those of the party on Graduates' Hall. A considerable number of paths were drawn upon the charts upon both evenings which will serve to determine the altitude, lengths, &c., of the trajectories, if the same have been observed elsewhere.

3. *At New Haven.*—Prof. Twining watched alone on the morning of Nov. 14th, giving special attention to the lengths of the paths, the duration of the flights, and the position and size of the radiant area. He says: "from midnight to 1^h A.M., looking toward Leo, I observed 35 shooting stars, in one hour, and in an area of about 110° of arc laterally, and 70° vertically. Of these there were 24 conformable from an area of radiation about 8° in diameter, whose center was in N.P.D. 65½° and A.R. 147½°. Two-thirds of all were directed nearly from this center. The sky was very clear. The conformable meteors were rather massive, with tracks about 1′ broad. Three were much broader, and left trains for 2^s to 6^s of time. The two longest flights that I observed were 20° and 22° of arc and about 1^s in time.

"Again I watched from 3^h 8^m A.M. to 4^h 8^m A.M., or one hour. In a space equal to the former and looking toward the radiant I saw 43 meteors, of which 38 were conformable to an area covering nearly the bend of the Sickle,—but far the greater number radiating closely from the small star in its middle, being the old radiant of Nov. 13th, 1833. The flights were generally from 5° to 15° long, and the longest 22° in $\cdot 7^s$ of time. The average of the 62 conformable flights, for the two hours, was about 10° of arc, in $\cdot 5^s$ of time. But the flights of the earlier hour were shorter than those of the later, while the times were longer. It is of course true that the velocity of meteors *must be retarded by the gaseous medium* in which their visible paths are developed. The force of this medium, condensed before their masses, is so great that, not unfrequently, a curve, or even an angle is described in a meteor's path. These sudden deviations—as well as the frequent explosions—may often be due to the meteor's passage from the *secondary atmosphere of the earth* (allowing this really to exist, as I have formerly suggested, and being composed, perhaps, of aqueous vapor) into its atmosphere proper.*

"Better means of determining the radiant—or rather the lines of flight—than the unaided eye affords are now necessary. The best I have thought of would be a conical shell mounted upon a pillar and rotated by clock work, like a telescope. The cone should have its axis directed to the presumed radiant,—its opposite elements spreading, say 90°,—its apex truncated to an opening but little greater in circle than the pupil of the eye, and its larger circle, or base, traversed by wires divergent from its center, at equal intervals, and these last supporting and normally

* This Journal, [2], xxvii, 20.

cut by a system of circular wires showing equal intervals of arc when viewed from the apex,—the whole combination appearing to the observer like the meridian lines and circles of polar distance in a stereographic polar projection. The open base may be slightly illuminated if the wires are not sufficiently visible against the sky.

"With this apparatus adjusted to a proper position of the axis, it is obvious that conformable meteors will traverse lines, along or between the divergent wires; and that the inclinations to the wires can be closely estimated, as well as the distances from the center at which the prolonged paths would pass. At the same time the parallel circles would, if properly disposed and designated, afford a scale to mark the beginning and the end of flights with the best attainable accuracy. The intersection of selected standard stars by the wires might be agreed upon, in common, to fix a position for the axes of the shells, in all places where they should be employed for comparative observations, although, if the axial position were ascertained in each case, that uniformity would not be indispensable."

4. *At Philadelphia.*—On the morning of the 13th Mr. B. V. Marsh saw in a half hour ending at $1^h\ 40^m$, 2 conformable meteors and 6 others; in a half hour ending at $4^h\ 36^m$, 5 conf. and 3 others. The weather was clear and bright. The number for the hour (16) corresponds with the number (18) for single observers on that night at New Haven. On the next morning Mr. Marsh saw in 36 minutes, between 12^h and 1^h, 23 conf. and 5 unconf. meteors. Later in the morning the sky was mostly overcast.

5. *At Newark, N. J.*—Mr. C. G. Rockwood, on the night of Nov. 12th–13th, watched from $10^h\ 45^m$ to $2^h\ 30^m$ A. M., omitting the quarter hour from $12^h\ 45^m$ to 1^h. The sky was clear except a haze near the horizon. The following table gives the results.

	Conf.	Nonconf.	Total.
From $10^h\ 45^m$ to $11^h\ 0^m$,	0	5	5
" 11 3 " 12 0,	2	23	25
" 12 0 " 12 45,	6	5	11
" 1 0 " 2 0,	16	15	31
" 2 0 " 2 30,	5	8	13
Total in $3^h\ 27^m$,	29	56	85

On the next night, with four assistants, he watched from $11^h\ 20^m$ to $2^h\ 40^m$, counting 261 meteors, as follows:

Time.	Conf.	Nonconf.	Total.	Duration.
$11^h\ 20^m$–$12^h\ 0^m$	13	43	56	in 40^m
12 0 –12 30	27	29	56	30
12 30 – 1 0	33	24	57	30
1 30 – 2 0	40	15	55	30
2 0 – 2 30	20	14	34	30
2 30 – 2 40	2	1	3	10
Total,	135	126	261	in $2^h\ 50^m$

For a good part of the time it was cloudy in the south and southwest and also low down in the northeast. After 2^h A. M. the clouds increased rapidly and soon covered the sky.

6. *At Poughkeepsie, N. Y.*—Seven of the pupils of Miss Maria Mitchell saw, at the Vassar College Observatory, 354 meteors in seven hours on the night of Nov. 12th–13th, and on the next night 419 were seen by six of them in five hours.

7. *At Canonsburg, Pa.*—Prof. Kirkwood reports 64 seen by six persons in 45 minutes, ending at $4^h\ 39^m$ A. M. of the 13th, of which about 50 were from Leo. The next night was cloudy.

8. *At Franklin, N. Y.*—Mr. William A. Anthony, with two assistants, counted on the morning of the 14th, between 2^h and 4^h, 180. On account of the cold it was impossible to stand still and watch the heavens, and one hour, or an hour and a quarter at most, would, he thinks, include the time they were watching.

9. *At Cambridge, Mass.*—Mr. F. W. Russell watched during several evenings in the first half of November. He has plotted 60 or 70 flights, which were remarkable for size or beauty, and reports 875 in all. The details have not yet been received.

10. *At Chicago, Ill.*—Mr. Francis Bradley reports 27 meteors seen by three persons in one hour ending at $2^h\ 30^m$ on the morning of Nov. 12th. On the next night five observers saw in the hour and a half ending at 1^h A. M., 65 meteors, of which 24 were from Leo. Clouds or haze prevented further observation.

11. *At Olivet, Mich.*—Prof. J. H. Hewitt, to whom on account of his previous experience in observing I had written requesting particular attention to the shape of the radiant area, watched on the night of Nov. 12th–13th, together with Mr. M. R. Gaines, from 11 to 5 o'clock. The night was mostly clear. He says: "of those which went from the Sickle, the tracks of the larger number, I think, were in the general direction of a line joining γ and ε, and these tracks were much nearer together than the tracks of those which proceeded in a direction perpendicular to that line. That is, supposing an ellipse to represent the radiant area, the larger diameter would be in the direction of $\gamma\varepsilon$. We frequently remarked that our observations coincided with your suspicions that the radiant area would be such an ellipse."

12. *At Detroit, Mich.*—Mr. O. B. Wheeler reports 56 for three observers for one hour from $2^h\ 20^m$ A. M. Nov. 13th. Forty-two were conformable. Clouds prevented observation on other nights.

13. Mr. Charles G. Boerner of Vevay, Ind., sends a chart upon which he has recorded the paths of meteors observed on the mornings of the 12th and the 13th. The next night was cloudy.

14. *At Iowa City, Iowa.*—A party of students of the Iowa State University, under the direction of Prof. Hinrichs, watched through the nights of Nov. 12th and Nov. 13th. During the first of these two nights the sky was mostly clouded except from

about one to three o'clock A.M., where it was pretty clear overhead. Thirty-five meteors were seen, of which twenty-two were in the hours named. Three persons were observing.

On the next night, Nov. 13th–14th, it was partially overcast until near 10 o'clock. The number seen was 440. The hourly number, the number of observers, and the state of the sky, are given in the following table.

Time.	No. obs.	No. seen.	Sky.	Time.	No. obs.	No. seen.	Sky.
$8\frac{1}{2}^h$– $9\frac{1}{2}^h$	3	4	Cloudy.	$12\frac{1}{2}^h$–$1\frac{1}{2}^h$	4	90	Clear.
$9\frac{1}{2}$ –$10\frac{1}{2}$	3	8	Partly clear.	$1\frac{1}{2}$ –$2\frac{1}{2}$	5	112	Clear.
$10\frac{1}{2}$ –$11\frac{1}{2}$	3	7	Some clouds.	$2\frac{1}{2}$ –$3\frac{1}{2}$	5	138	Clear.
$11\frac{1}{2}$ –$12\frac{1}{2}$	4	61	Clear.	$3\frac{1}{2}$ –$4\frac{1}{2}$	5	20	Clouding.

Soon after $3\frac{1}{2}^h$ A.M. the sky became wholly overcast. The next night the sky was also entirely covered.

15. *At Washington, D. C.*—Observations were made at the U. S. Naval Observatory which will soon be published in full.

16. *In Bay of Panama.*—Mr. Frank H. Bradley writes to Prof. Twining, that with about a quarter of the sky clear he counted eleven meteors between 1^h 45^m and 2^h 30^m A.M. on the morning of Nov. 13th. The sky then became overcast.

On the next morning he was on deck from 2^h to 3^h A.M., and in that time counted 30 meteors, 17 of which seemed to be radiant from a point near the horizon in the N.N.E. The sky was clear from N.E. to N.W. and a little past the zenith, but about 3^h A.M. the clouds closed entirely.

On the night of the 14th–15th he was on deck for some time, with much clear sky, but saw no meteors.

17. I am indebted to Prof. Henry, who has kindly placed in my hands for examination the reports received by the Smithsonian Institution from various observers.

Prof. Hopkins of Williams College gives the times of 205 meteors on the night of the 12th–13th, of 453 on the next night, and 4 on the third night. The apparent paths of a large proportion of them is also given. The following are the numbers for the successive hours.

Time.	12th-13th.	13th-14th.	Time.	12th-13th.	13th-14th.
Before 7^h	1	6	12^h–1^h	2	51
7^h– 8	2	9	1 –2	10	71
8 – 9	0	19	2 –3	45	53
9 –10	7	16	3 –4	40	61
10 –11	10	21	4 –5	41	69
11 –12	23	33	5 –6	24	44

Between 11^h 30^m P.M. and 2^h 15^m A.M. of the first night the clouds interfered seriously, and sometimes even covered the sky. This series of observations will no doubt prove to be of special value for the computation of altitudes.

The reports received by the Smithsonian Institution from a large number of other observers will be of value for the same purpose.

18. Two meteors deserve special notice. One at $11^h\ 7^m$, Nov. 13th, appeared at New Haven low in the Lynx, and passing a little north of the zenith, crossed Andromeda between α and β, and disappeared low in the S.W. having described a path of 135°. I was at first a bright point, but after a time burst out into a flame and left a train for several seconds. The duration of flight was called four seconds. At Newark and Philadelphia the same star described a similar long arc. At Williamstown it appeared 5° from Mars towards Canis Minor, and ended ½° S. of Diphda; duration 7 seconds. These data give the first altitude 88 miles (142 kilometers), the least altitude 66 miles (106 km.), and the length of the path, according to the Williamstown observation, 325 miles. It must have passed beyond Diphda, however, as seen from that place, since it disappeared in the S.W. at Philadelphia. Seven seconds for 325 miles gives 46 miles per second for the velocity, a result probably too great.

19. At 11 minutes past 2 o'clock A.M., Nov. 14th, a very bright green (or blue) meteor appeared, at New Haven, in R.A. 148°, Dec. +16½°, and went to R.A. 143½°, Dec. +9°, leaving a train about 4° long. This train floated away 8° to the north in a path parallel to the horizon, being visible for 9 minutes. Before disappearance it had become shorter and broader so as to be 2° or 3° long and 1½° broad.

The same meteor was seen in Newark by Mr. C. G. Rockwood to descend vertically, ending at R.A. 163°, Dec. +15½°. The cloud or train floated also northward, parallel to the horizon, crossing δ Leonis. A corresponding path is given by Mr. Henry M. Parkhurst of Brooklyn.

At Williamstown the record was "origin 20° south of Regulus; course W.S.W.; length 40°; blue trail."

The first altitude was then about 120 miles (193 km.), the altitude at disappearance about 60 miles (97 km.), and the length of path 115 miles.

The cloud as seen from Newark bent up as is usual with such trains, while at New Haven it only grew shorter and broader, a result doubtless of perspective. The meteor's distance from New Haven at disappearance was 120 miles, and the cloud was doubtless still farther from us. Hence its length must have been more than 5 miles and its breadth over 3 miles. The true motion of the cloud was northward, at right angles to the motion of the meteor, being in nine minutes at least 17 miles, and probably about 20. It was evidently due to a current in the atmosphere, whose velocity was about 125 miles per hour.

The material of the meteor must have been considerable in order to have filled several cubic miles with its debris. And yet this debris must have been very attenuated to float in an atmosphere so light as that which is 60 or 90 miles from the earth's surface.

20. The great display which was looked for with such general interest both in this country and in England was witnessed in Europe early on the morning of the 14th.

At Valentia, Ireland.—The following is an extract from a letter from Dr. B. A. Gould, who was at Valentia, Ireland, engaged in determining the longitude of American stations by means of the Atlantic cable.

"At $12^h\ 30^m$ (Greenwich time) meteors were so abundant that I caused the telegraphic staff to be aroused, in confident expectation of a 'meteoric shower.' From this time to about $2^h\ 25^m$ A.M. the sky was quite clear (except for six or seven minutes), not more than one-fourth part being at any one time obscured. At 1^h A.M. the sky was brilliant with meteors of every degree of brightness, from the 4th magnitude to 15′ diameter, and the brilliancy of Jupiter. The largest ones, and certainly there were fifteen or twenty such, were as brilliant and large as a ship's rocket at half a mile distance.

"The comparatively slow and uniform movement of most of them, their long bright trains, and pure white light, presented a strong resemblance to a flight of rockets.

"The center of divergence was in Leo, then not high in the east. The radiant was not well defined, but a locus of probably a degree and a half in diameter. I think that I observed ten or twelve of which the paths produced would form tangents to such a circle.* During the whole display I saw but two unconformable meteors, both of them faint. * *

"Between $12^h\ 39^m\ 0^s$ and $1^h\ 5^m\ 0^s$ I counted 310. * * * With the aid of a friend, who faced south while I faced north, I counted 203 during the 90 seconds between $1^h\ 9^m\ 0^s$ and $1^h\ 10^m\ 30^s$. Ten minutes later the frequency seemed to have much diminished.

"At $1^h\ 38^m$ there were not more than 65 or 70 to the minute, and frequently five or six seconds would pass without any being seen.

"Between $1^h\ 45^m\ 15^s$ and $1^h\ 46^m\ 15^s$ (1^m) only 23 were seen.

"	1	49	0	"	1	51	0	(2^m)	"	22	"
"	1	58	0	"	2	1	0	(3^m)	"	17	"

"At $2^h\ 15^m$ they seemed scarcely more numerous than on an ordinary August night."

21. *In Exeter, England.*—Mr. J. T. Tucker, of Exeter, in a letter to the writer states that he counted 954 meteors between $12^h\ 30^m$ and $1^h\ 30^m$ A.M. of Nov. 14th.

22. *At Manchester, England.*—Mr. Joseph Baxendell, F.R.A.S., devoted special attention to the place of the radiant, and the time of the maximum. He gives for the former, R.A. 149° 33′, Dec. +22° 57′·5, which is the mean of a number of observations. For the time of maximum frequency he gives $1^h\ 12^m$ A.M. (Gr. time), and thinks that the probable error cannot exceed one minute. He saw the shower of 1833, being then at sea off the west coast of Central America, and says that the present display

* A diagram gives the center of this circle as about R.A. 148°, Dec. +23½°.

was far inferior to the former, both in the number of meteors seen and in the brilliancy of the larger ones.*

23. *At Greenwich.*—According to an extract from the *London Herald*, the hourly numbers seen at the Greenwich observatory were as follows:

9^h–10^h	10	meteors,	12^h–1^h	2032	meteors,	3^h–4^h	528	meteors.
10 –11	15	"	1 –2	4860	"	4 –5	40	"
11 –12	168	"	2 –3	832	"	Total,	8485	"

24. *Thickness of the group.*—The inclination of the plane of the group to the ecliptic is probably about twice the latitude of the radiant, or 19°. The denser part of the shower was included in a period of about $1^h\ 30^m$; and during this time the earth moved about 100,000 miles. The corresponding thickness of the group would be 100,000 sin 19°, or 33,000 miles. The density gradually diminishes as we leave the center of the group, and the thickness, including these rarer portions would be much greater.

25. *Geographical limits of the shower.*—The sun was vertical at $12^h\ 30^m$ A.M. (Gr. time) in E. lon. 168½°, S. lat. 18¼°. If this time be taken for the beginning of the shower as a great display, and if 10° be allowed for twilight, a line crossing the equator in E. lon. 68½° and running N. 18¼° E. separated daylight from darkness and forms the eastern limit beyond which the shower was not probably visible.

The radiant was vertical at 2^h A.M. (which may be taken for the end of the shower) in N. lat. 23½°, E. lon. 65°. The western limit would be a great circle of which that point is a pole, to wit, a line crossing the equator in W. lon. 25°, and running N. 23½° W. This line passes from Newfoundland through the center of the two Atlantic oceans. Regions west of this line were behind the earth throughout the shower. Along this line a few meteors with long paths were probably visible.

26. If there shall be a shower in Nov. 1867 (and it is quite probable that there will be one), and if the group lies sensibly in a plane, these limiting lines would be removed 90° or 100° westward. But what curves in the line of the group have been produced by the perturbing action of the earth, of Jupiter, and of the other planets we cannot say. Such curves apparently exist, and may change the time of maximum, and therefore the region in which the shower may be expected next November.

When full and authentic reports from English astronomers shall be received I hope to resume the subject.

* Proc. Man. Lit. and Phil. Soc., vi, 31.

ART. XIII.—*Correspondence of Prof.* JEROME NICKLÈS, *dated Nancy, October 2d,* 1866.

Obituary: Hermann Goldschmidt, the Astronomer.—The subject of this notice attained to a considerable reputation as an artist, but he is better known to the scientific world, in which he held a high position, by his numerous discoveries among the heavenly bodies.

He was born June 17th, 1802, but during his whole life his health was delicate. Destined at first to commerce, he quitted it to devote himself to painting, and early became distinguished in that career. He was, however, ignorant of his true vocation until he had attained the age of forty-five years. One of his friends, Dr. Hoefer, to whom we are indebted for these details, tells us the circumstances under which he became an astronomer. The recital is copied from Goldschmidt himself. "I had just returned," says he, "full of disgust from a very long sojourn in England. I tried in innumerable ways to dissipate my melancholy humor, but without success, when one day I chanced to attend LeVerrier's lecture on astronomy. The professor explained an eclipse of the moon which was to take place the same evening (March 31st, 1847). I understood the explanation, and in my enthusiasm I exclaimed *anch' io son.* From that moment I commenced with ardor to study a science of which I had as yet only the feeblest notions."

Three years after, Nov. 15th, 1852, Goldschmidt discovered, with a small glass which he had just bought, a planet which received from Arago the name of *Lutetia*, having the brightness of a star of the 10th magnitude. The 26th of October he discovered *Pomone*, which resembled a star of the 11th magnitude. He afterward successively discovered the following: *Atalante*, Oct. 5th, 1855; *Harmonia*, March 31st, 1856; *Daphne*, May 22d, 1856; *Nysa*, May 27th, 1857; *Eugénia*, July 11th, 1857; *Melete*, Sept. 9th, 1857; *Palés*, Sept. 19th, 1857; *Doris*, id.; *Europa*, Feb. 6th, 1858; *Alexandra*, Sept. 10th, 1858; *Danae*, Sept. 19th, 1860; *Canope*, May 9th, 1861. By reason of these discoveries he several times received the astronomical prize from the Academy of Sciences. He also determined the position of more than ten thousand stars which before had no place upon any known map of the heavens—and it was among these stars that he found the planets previously enumerated.

He made these discoveries with a small glass—and his observatory was situated in one of the most frequented streets of Paris. Not favored by fortune, Goldschmidt lived on a pension paid him by the French government. For a long time he had been troubled with his eyes, but this affliction affected him much less

than diabetes, the symptoms of which he first felt in 1854. He then retired to the country, and for three years lived at Fontainbleau, dividing his time between painting and astronomy. Toward the latter part of last August his disease became complicated with other difficulties. He hastily finished his papers upon the physical constitution of the sun, and died on the 20th of August. He leaves a widow and two daughters without fortune. They will doubtless be adopted by the "Société de Secours Amis des Sciences."

Spectrum of aqueous vapor.—We now know the nature of the rays which Brewster discovered in 1833, and which have since been termed telluric or atmospheric. M. Janssen has made several investigations under the patronage of the Minister of Public Instruction, and has found that these rays are occasioned by the vapor of water. By means of new optical dispositions he has proved that the bands of Brewster were formed of fine lines, like the lines of Fraunhofer, and that they were constant in the spectrum, though of variable intensity according to the height of the sun. Relying upon this character of the telluric rays he has made a chart of the spectrum in which the distinction between the solar and telluric rays is clearly shown.

Janssen has also made numerous other experiments. In September, 1864, from the summit of the Faulhorn, he observed the rays of terrestrial origin and found they became weak in proportion as they were elevated and as the light had less thickness of atmosphere to traverse. In the same year he made an experiment upon Lake Geneva, and by reason of the humid air of the lake he was able to reproduce the same rays artificially. The flame from a large pile of pine wood at the distance of 21 kilometers presented these lines, but when viewed at a less distance no ray was visible except the brilliant one of sodium. Janssen stationed himself on the side of the lake opposite the fire, so that the light from the blazing pile, which was on a level with the surface of the water, might penetrate strata of air saturated with moisture.

It was necessary to ascertain if these effects were caused by the water in solution in the atmosphere, or whether, as Mr. Secchi thought, they were to be attributed to the vesicles of which mist and fogs are composed. A direct experiment confirmed him in the opinion that they were produced by the vapor. Janssen operated with a tube thirty-seven meters in length, which was filled with vapor by a steam engine of six horse-power. Care was taken to prevent the tube from cooling, and the light was furnished by a flame of gas placed in the axis of the tube. When the light passes through the tube filled with vapor subjected to the pressure of seven atmospheres it shows the principal telluric rays, among which Janssen places the

groups A and C and a large part of B, contrary to Kirchhoff, who attributes A and B to potassium. The red and yellow of the spectrum of water-vapor are more brilliant than the blue and violet. Therefore the color of the vapor of water should be orange; hence, also, the red of the setting sun, that is, of the sun seen near the horizon. Janssen does not agree upon this point with the conclusions of Prof. Cooke, which were published in this Journal for March, 1866. According to the latter the vapor of water absorbs most completely the yellow and the red rays, hence the blue rays predominate in the spectrum that is transmitted. Prof. Cooke has, however, discovered and demonstrated by his own researches (this Journal, [2], xli, 184, also Journal de Pharmacie et de Chemie, June, 1866, p. 480), the influence of the vapor of water upon the phenomenon in question.

A new property of magnesium.—One evening while preparing some perchlorid of manganese, $MnCl^2$ (this Journal, [2], xli, 107), with the peroxyd of manganese, the chlorhydric acid of commerce and ether, I observed that the color was not green, as it appeared to be in the daytime, but *black*. I was using gas for a light, and substituted in place of it first an oil lamp and afterward a wax candle, but the effect was the same, the color still appeared only black.

The *green* color reappeared by the flame of magnesium, which comports itself in this respect like the light of the sun. It is well known that bright-tinted flowers, colored stuffs, or pictures, exhibit much less brilliancy of coloring by wax or even gas light than when seen by the light of day, and should an artist, at the close of the day, wishing to supply the waning light, continue his work by the aid of wax lights or gas, he would be surprised the next morning at the assemblage of colors he had made the evening previous. They would in no way represent his thought, so different would they appear when viewed in the two lights.

By burning a thread of magnesium a light may be obtained which will make these colors appear the same as when seen by sunlight itself. Colors do not mingle or interchange by this light as they do by ordinary lights. Green does not appear to be blue in it, neither does blue have the slightest appearance of green. In short, all shades preserve the same appearance as when viewed in the full light of day. The flame of magnesium is whiter than solar light, and the blue predominates in it. Chemistry aids the painter not merely by furnishing colors more or less bright, but it now gives him a new mode of illumination by means of which he can labor at night without fear of optical deception, as well as if it were daylight.

The influence of sodium upon flame.—On inquiring the reason for the extinction of color by the usual flame, which we have

just been discussing, it will be found that numerous causes produce this effect, one of which is *sodium*, which burns with a *yellow* (monochromatic) flame, that may be obtained either by bringing common salt supported on platinum wire into the flame of the Bunsen lamp, or by burning alcohol saturated with salt. All the colors are altered by this flame, with the exception of blue-violet, which is complementary to the yellow. Red appears black or white, sometimes bluish when it contains blue (see below, *physiological effects*). Mixed green appears *yellowish* or bluish (chlorophyl Schweinfurth green). The pure greens appear black (ex. $MnCl^2$, $MnBr^2$, MnI^2 combined with ether, $BaO\,MnO^3$, Cr^2O^3, gold leaf seen by transmitted light, Cr^2Cl^3, &c.). Vide Annales de Chem. et de Phys., [4], viii, 298, for the enumeration of the various colors which have been experimented with.

The following table gives the result of some trials which I have made with a spectrum prepared by applying pigments to white paper. We give the composition of the spectrum and the colors with which it was obtained.

Colors seen by daylight.	Coloring material.	Colors seen by a monochromatic flame.
Red.	Ochre (Fe^2O^3), - - -	Black.
Orange.	Iodid of mercury (HgI), }	White.
Yellow.	Chromate of lead ($PbOCrO^3$). }	
Green.	Manganate of baryta, } - -	Black.
Blue.	Aniline blue, }	

In this spectrum so wonderfully changed by the flame of alcohol saturated with salt, sunlight and the flame from magnesium instantly restored the normal colors, even while the sodium flame was burning in the neighborhood. They also reappeared by gaslight, but with much less intensity, and when the colors are not very brilliant they are modified as if they were illuminated by the soda flame.

Thus etherial solution of perchlorid of manganese when impure appears by gas light *black* instead of *green*. A mixed green composed of chromate of lead ($PbOCrO^3$) and ultramarine behaves in the same manner.

If the illuminating flame were saturated with sodium its extinctive effects would be still more energetic, ordinary flames containing but very little of this metal. Spectral analysis shows us that instead of completely extinguishing colors it merely alters them a degree more or less, darkening some and enlivening others, and creating confusion between blue and green.

The small quantities of sodium which all ordinary flames contain, are derived from several sources, viz., the mineral matters of wicks of lamps and candles, ashes of fuel and atmospheric air, which last, according to Bunsen, always contains traces of it.

Vogel has determined the proportion of soda which illuminating gas contains (Journ. de Pharm. et de Chem., October, 1866), and Mulder has shown (in the same Journal, May, 1866), with what facility marine salt volatilizes when heated with coal.

Small as the quantity of sodium is which illuminating gas contains, it is sufficient to affect certain colors, and to produce on a small scale all the effects of absorption or extinction which are readily seen in a flame saturated with it. Examples of this may be seen in certain green colors mentioned above.

Physiological effects of the monochromatic flame.—The foregoing results explain a well known phenomenon, which has hitherto never been accounted for. In the flame of alcohol and salt, the hands and face appear of a *livid green* hue, while the lips change to a *blue-violet.* This livid tint is known to all who have seen punch or a pudding burn, and is due to the alcohol more or less saline which is employed in these mixtures. Workmen at furnaces and forges are familiar with these peculiar tints, which appear upon the features illuminated by their fires.

In the first case the effect is produced by the NaCl which the alcohol contains of itself or which it derives from the alimentary substances; in the latter case the soda is obtained from the dross, and ashes of the combustible matters. The question arises, why under these conditions, the natural flesh color is changed to a *bluish* or livid green. The reply is evident. It has been shown above, that the colors which best resist the extinctive effects of the soda flame are those which come from blue.

That there is blue in human blood may easily be seen by the color in daylight of the large veins on the skin of the hand. All the other tints which enter into the composition of flesh color being extinguished except the blue, that shade alone remains upon the face of the experimenter, but being also illumined by a yellow flame, it is plain that the effects of the two colors will be to produce a *green*, varying in shade from yellowish to bluish according to the intensity of the blue, and producing a most sinister aspect on the human countenance. The eye speedily accommodates itself to these effects, but I have good reason for thinking that one cannot with safety, continue to work for any great length of time by this monotonous light. The retina after a time becomes so much affected as not to be able to bear without irritation either daylight or the ordinary illumination used at night, a result possibly caused by the absence of chemical rays in the flame, or because it injures the optic nerve which is poorly adapted to such a medium.

After sitting for a considerable time in the soda light, there comes a time when it is difficult to distinguish between the different shades of the same color. I have many times seen a tuft of leaves appear of the identical shade of the hand which held it, so

that the whole had the effect of a bronze, while at the beginning of the experiment before the eye had become fatigued, it was easy to distinguish between the violet of the chlorophyl and the livid green of the flesh color.

Employment of the Sodium flame by artists.—We have previously shown that the different colors of the spectrum may be reduced to white or black, unless they contain blue which is the only color unaffected by the soda flame.

In observing such a spectral image it will be noticed, that if all the colors are reduced to either white or black, the borders are more or less darkened or dulled as in a photograph of the spectrum. Looking at a painting, especially a pastel containing very little if any blue, under these conditions, one is struck with the fact, that although the colors vanish, the grayish tone which represents them gives the appearance of a pencil drawing. The model or plan exists by reason of the half tints so that by the monochromatic light, one is sometimes able to go back to the design without touching the picture and can thus give in some sort the autopsis of a work of art.

The flame of sodium may yet aid the painter in comparing shades, in grouping colors and weighing their tones.

In the same manner, two colors, for example two *greens* which appear identical upon the palette, in the daytime, may be different when seen by common evening light, and are more likely to differ when viewed by the sodium flame, one being decolorized and the other transformed into black. In the same manner, of two *reds* seen under the same conditions, one may appear white, while the other containing *blue*, will assume a *violet*-tint complementary to the yellow of the monochromatic flame.

Common salt ignited on a platinum wire in the flame of a Bunsen burner, strikingly exhibits the chemical differences which sometimes exist between two similar shades of color. This means may be useful in distinguishing original pictures from copies, for it is not likely that Raphael or Van Dyck, for instance, exployed exactly the same pigments as their copyists have used.

If one desire to render the flame of a gas burner or of an oil lamp monochromatic, it cannot be done with NaCl, for the flame is not hot enough to volatilize that compound. Metallic sodium should be used for this purpose, which may be introduced into the gas burner or held in the flame upon platinum wire.

Perchlorid of Lead, $PbCl^2$.—In connection with what we said last year (this Journal, [2], xli, 107 and 55) upon the halogen compounds corresponding to the peroxyds, we have since obtained the compound $PbCl^2$ corresponding to the peroxyd of lead PbO^2. Unstable in a free state, it may be preserved for a long time in presence of a solution of chlorid of calcium.

It is prepared by passing a current of chlorine into chlorid of

lead held in suspension in a solution of CaCl of 40° Beaumé. The liquid becomes yellow and acquires very curious properties. Thrown into a small quantity of water, it gives a precipitate of PbCl—with excess of water a brown precipitate is formed of PbO^2. $PbCl^2+2HO+Aq=PbO^2+2ClH+Aq$.

In this case the hydrochloric acid does not react, because of the excess of water present, if there were less the result would be $PbO^2+2ClH=2HO+PbCl+Cl$.

The perchlorid of lead does not act upon the nitrate of bismuth, behaving in this respect differently from $TlCl^3$ (this Journal, [2], xli, 107). When heated it blackens cane sugar but not glucose, and hence may serve to distinguish between these two kinds of sugar.

Treated with anhydrous ether and syrupy phosphoric acid, the solution of perchlorid of lead thickens, and yellow oily drops appear, which are perchloro-plumbic ether. This ether readily dissolves gold, and as the metal is taken up chlorid of lead separates assuming the form of the gold employed. The perchloro-plombic ether readily decomposes; the products are protochlorid of lead and chlorinated ethers. The ease with which chlorine separates from it, is the cause of its solvent power on gold, in which respect it is like the bodies presently to be noticed.

New solvents for Gold.—The perchlorids dissolve gold readily when that metal is in the form of leaf, on account of the facility of their decomposition with liberation of chlorine. If ethereal solution of perchlorid of manganese be employed, the green color of the manganese compound grows lighter in proportion as the gold dissolves, for $MnCl^2$ is reduced to MnCl, and the reaction is complete, when the liquid has exchanged its green color for the yellow of the solution of gold, (it is the same with $MnBr^2$ and MnI^2).* On evaporating the liquid, a film of gold adheres to the vessel. The same solution added to $FeOSO^3$ yields the precipitate of gold so characteristic for its dichroism.

The sesquichlorids, and the sesquibromids which are easily reduced—for example, the compounds corresponding to Mn^2O^3, Ni^2O^3, Co^2O^3; also Fe^2Br^3 even in presence of a certain proportion of FeBr—dissolve gold; Fe^2I^3 is also a good solvent for gold especially in presence of ether. It is only necessary to add a small quantity of Fe^2O^3 to the ethereal solution of iodhydric acid, in order to dissolve the metal. This proves that iodine in the nascent state acts upon gold. For this reason gold is acted upon even by iodhydric acid *in presence of ether.* No action takes place when only water is present. It can no longer be said with truth, that free iodine does not act upon gold. I have found that gold may be dissolved by it in presence of water,

* This Journal, [2], xli, 107.

when put into a close vessel and raised to a temperature of 50°. The action is more slow if ether is used in place of water. Exposure to strong sunlight will hasten the solution.

Some new facts concerning amalgamation.—In vol. xli, p. 225 of this Journal, Prof. Silliman has described some properties of the *magnetic amalgam*, composed of mercury and sodium. The following experiment readily shows the great difference between the action of mercury and that of sodium amalgam.

Take a square of glass, to which apply side by side two leaves of beaten gold. If a drop of ordinary mercury be placed on one of these leaves, it adheres without sensibly increasing in area. On the contrary a small drop of the amalgam spreads out with great rapidity, so that in a few seconds the mercury has covered a space many hundred times larger than that which the original drop occupied.

I showed in 1853 (in this Journal)* that the metals moistened by mercury are permeable to it; that proposition has been verified upon the metals since discovered or prepared, viz., *thallium*, *aluminium* and *magnesium*. Thallium is easily amalgamated, and becomes brittle by the penetration of mercury; on the contrary, magnesium and aluminium resist its action or are not wetted by it until recourse is had to electric action, such as is realized by the intervention of sodium or zinc.

It would be interesting to observe the deportment of *indium* toward mercury. If it were capable of being moistened it would form with it a brittle amalgam; on the other hand, if it were not moistened it would retain all its elasticity. I leave the question to those who are fortunate enough to possess this metal so rare, and so difficult to obtain in a metallic mass.†

Chemical synthesis.—M. Berthelot continues his beautiful researches in synthesis, and is at present occupied with the generation of hydrocarbons. Our readers know that he formerly obtained acetylene, C^4H^2, by the direct union of hydrogen and carbon (this Journal, 1862). Berthelot has lately shown that a whole series of hydrocarbons, polymeric with C^4H^2, may be derived from it as follows:

Acetylene,	$C^4\ H^2$	
Di-acetylene, - - -	$C^8\ H^4$	$=2C^4H^2$
Tri-acetylene or benzine, -	$C^{12}H^6$	$=3C^4H^2$
Tetracetylene or styrolene, -	$C^{16}H^8$	$=4C^4H^2$
..... - -	.....	
Retene, - - - -	$C^{36}H^{18}$	$=9C^4H^2$

This table is the result of actual experiment and not of theoretical speculation.

* J. Nicklès, On the Permeability of Metals to Mercury, [2], xv, 107.

† A sheet of platinum that has been for four months in contact with amalgam of sodium still preserves all its elasticity.

Berthelot has observed still another series of hydrocarbons, between styrolene and retene, the boiling point of which is between 250° and 340°, and which possess to a great extent the characteristic fluorescence of pyrogenic oils of resin. Berthelot regards these hydrocarbons as C^4H^2 six, seven, and eight times condensed. Between 210° and 250° there passes over a liquid which, when placed in a freezing mixture, yields crystals of naphthaline. The origin of this interesting hydrocarbon is easily explained, naphthaline being in fact only pentacetylene less H^2.

$$\underbrace{C^{20}H^{10}}_{\text{Pentacetylene.}} - H^2 = \underbrace{C^{20}H^8}_{\text{Naphthaline.}}$$

Naphthaline is produced equally well when acetylene is passed into a tube heated to redness. There is, however, in this case but a small quantity formed, for the acetylene is chiefly decomposed into carbon and hydrogen.

Acclimation of the Camel in Australia.—The introduction of the camel into Australia has been previously announced, and it was effected by the "Société d'Acclimatation." We now learn that these animals have adapted themselves to that country, as has been shown by a recent expedition consisting of seventy horses, fourteen camels, and fifteen men. The springs of living water upon which they depended having been dried up, sickness broke out in the camp. The men fell back upon their stores of spirituous liquors, the horses took to flight, while the camels alone remained at their post. It is owing to this circumstance solely that the expedition was reorganized. At last accounts the caravan had arrived at Thompson river.

Acclimation of the Salmon.—The eggs of the salmon which have been introduced into the waters of Australia have hatched and the young fish are prospering. Ice has been used in the transportation of the eggs, which, according to Mr. Youle, retards the phenomena of embryonic evolution. This gentleman has found that the vitality of the eggs may thus be preserved for three or four months. It is in this manner that eggs taken from the Rhine at Huningen in Alsace have been successfully transported to Australia. Sweden and Norway are both occupied in stocking their rivers with salmon, so that the fine example of the Zoological Society of Acclimation will not be lost.

Spontaneous generation.—This interesting question is from time to time discussed by the Academy of Sciences, but without much progress being made toward a decision. Mr. Donné, a naturalist who formerly opposed the doctrine of spontaneous generation, has made some late researches which have caused him to change his mind on the question, and he has just ranged himself on the

side of Messrs. Joly, Musset, and others, giving it as his opinion that spontaneous generation is a possible fact.

His later experiments, like those which he published an account of in 1863, were made with eggs. At that time he wrote: "The matter of which the egg is composed ought to be eminently suited to a primitive organization. I will leave the entire eggs to themselves, and when the alteration of their contents has well progressed, I will examine with the microscope the interior substance. If spontaneous generation is possible I ought to find organized beings there." The result was negative. Mr. Donné found neither mold nor infusoriæ, and he decided against spontaneous generation. Since then objections have been raised which decided Donné to resume his experiments. He reasoned thus: "The small quantity of air contained in the eggs was perhaps not sufficient to determine the phenomenon of a spontaneous generation, that is, to give life to a certain molecular arrangement of organic matter." Consequently he conducted his experiment in such a way that a larger quantity of air could have access to the eggs, the air having been previously deprived of any bodies it might hold in suspension, by passing through carded cotton. This time he obtained a generation of different kinds of mold, but found no traces of animalcules. He concludes 1st, "Microscopic vegetation may be produced at will in organic matter, left to itself, and protected from the intervention of foreign germs. 2d. Air is necessary to the development of infusorial animalcules. 3d. Air is indispensable to spontaneous generation in both kingdoms. The temperature of 30° is the most favorable to these productions."

To these conclusions the adversaries of the doctrine oppose their usual objections, viz., there were sources of error in the experiment, atmospheric germs in some way penetrated the eggs of which the shells were broken. The question thus remains still at the same point, and up to the present time it cannot be said to be experimentally resolved.

Mexican Scientific Commission.—This commission, instituted by M. V. Duruy, Minister of Public Instruction, continues its labors, which will perhaps be the only work to survive the unfortunate intervention of the French in Mexico. The commission is engaged solely with science, and may be judged of by what has formerly been said of it in this Journal, (Jan. 1866, p. 110). The third part of the second volume of its publications has appeared, containing geological papers by J. Marcou upon the frontiers between Mexico and the United States; by MM. Dolfus, Pavie, &c., upon Mexican volcanoes; and the geological sections from Vera Cruz to Mexico. Other papers are reports upon the Mexican fauna and flora, also upon the ruins of Uxmal and Mayapan, Ti-hoo and Izamal, &c.

Bibliography.

Traité des propriétés des figures, par le General PONCELET. 2d edition, 2 vols. in 4°, avec planches.—This work, which is a complete *exposé* of this important subject, contains also the principal discoveries which the illustrious general has made in this department of inquiry. He has been engaged on the work since 1812, and was occupied with it when taken prisoner of war in Russia on the retreat from Moscow. The second edition, besides many improvements, contains *the general theory of the centers of harmonic means; polar reciprocity; analysis of transversals*, and their principal application to the projective properties of curves and geometric surfaces.

Cours d'algébre superieure, par SERRET, Membre de l'Institut, Prof. au College de France, et à la Faculté des Sciences des Paris. 3d edit., 2 vols. in 8vo.—The first two editions of this work were disposed of with great rapidity. The third contains many improvements by the author. While this learned man does not pretend that the work is a *complete* treatise upon higher algebra, it contains notwithstanding a body of doctrine which will be of great use to those geometricians who are engaged in this important branch of mathematical analysis.

Traité d'Astronomie pour les genes du monde. 2 vols. in 12mo, avec 2 planches and 162 figs. dans le texte.—This work contains a resumé of the lectures which Mr. PETIT has given during the last 27 years at the Observatory of Toulouse, of which he was director. The treatise is elementary, but calculations are not excluded. There are besides, in the form of notes, details and anecdotes in respect to important discoveries as well as distinguished astronomers.

Eléments de Mécanique, par Mr. VIEILLE. In 8vo, de 256 pages avec figures.—Vieille is Inspector General of the University of France. This work of his is designed for the use of the various colleges, and is fully adapted to that purpose.

Le Chimiste: a Journal of Chemistry applied to Arts and to Agriculture; published by HENRY BERGÉ, Professor of Chemistry at the *Museé de l'Industrie* at Brussels.—This journal appears semi-monthly, costs but 8 francs per year, and, according to its title, contains the novelties in the department of chemistry applied to the arts. Each part consists of 16 pages 8vo.

ART. XIV.—*On the supposed Tadpole nests, or imprints made by the Batrachoides nidificans* (Hitchcock), *in the red shale of the New Red Sandstone of South Hadley, Mass.;* by CHARLES UPHAM SHEPARD.*

No impressions belonging to this or any other geological formation surpass if they equal these in their extreme delicacy of surface and sharpness of outline, rivaling as they do in these respects the most perfect metallic castings. Dr. Hitchcock, by whom they were first described, has well observed concerning them, that even viewed by the side of the splendid specimens of foot-prints, rain-drops and other rock-markings displayed in the Ichnological cabinet of this college (Amherst), "they are the most attractive of all."

Dr. Hitchcock was led to conceive of and adopt the theory of their origin first suggested and made public by Prof. Silliman, Jr., and the late Capt. N. S. Manross, viz., that they proceeded from the gyratory movements of tadpoles; though he very cau-

* Several excellent photographic representations accompanied this paper, which are omitted, as it was impossible to do them justice on wood.

tiously observes, "in concluding that the impressions were made by batrachians similar to those now living, I am by no means free from doubts as to the identity of the phenomena."* The single figure he has given† (Pl. L, fig. 1) of these markings, if taken by itself does certainly favor the hypothesis adopted; though it fails in its uninterruptedly smooth and continuous surfaces as compared with the rough and broken sides of the recent tadpole cavities,—not to mention the rounded borders to the edges of the latter, when contrasted with the hexagonal outline of the corresponding part in these specimens. The cavities made by tadpoles morever are without any order in respect to each other, and vary somewhat among themselves in size and depth. Occasionally also, unoccupied spaces are seen between the holes, whereas in the shale nothing is more striking than the general uniformity among the impressions, and the very complete manner in which the entire surface is covered by them,—raised lines (sometimes resembling swollen veins), being the only boundaries between contiguous cavities.

The slabs of shale present three rather distinct varieties of these impressions, one of which is very accurately represented in the plate above referred to. In this the depressions are imperfectly arranged in rows, with a marked tendency to a concentric arrangement. The borders of the cavities are distinctly hexagonal, and the edges often equilateral. The cavities have a depth equal to about one-eighth their diameter. They are perfectly symmetrical, smooth and glossy. In a few of the specimens, the sides and bottoms are slightly pitted with ovoidal bodies of the size and shape of coarse gunpowder. The slab removed from such a surface of course exhibits upon its convexities corresponding granules in relief. As they are distributed without any order, and not generally present, they would appear to be due to seeds, as these of a larger size and spherical form are frequent in the formation.

In the second variety we have little more than the strongly nerved outlines of the hexagons. The cavity is shallow, or nearly obsolete; but on its bottom, and proceeding from one and the same side relatively in each impression, is often seen a tripartite, flame-like marking, or brush, which spreads over nearly half the area. The direction of this fan-shaped brush is constant throughout the series, thus evincing an origin from a common cause, and one that acted simultaneously. The impressions moreover are occasionally traversed by raised lines proceeding from a subjacent layer, and thereby subdivided into smaller compartments; but in these instances it is always easy to trace the hexagonal boundaries of the superior layer. The depressions are obviously arranged in rows, somewhat approximating to fur-

* Ichnology of New England, 4to, 1858, p. 122. Boston. † Idem.

rows, the parallel sides of which are more conspicuous than the transverse edges which subdivide the furrows into cells.

It may here be observed that the fan-shaped brush is scarcely at all visible in the first described variety. The diameters of the cavities in both are the same, being from one to one and a half inches. The differences in the depth of the cavities in the two varieties probably grew out of the hardness of the bottom where they originated.

The second kind, or shallow impressions, are constantly associated with the third variety presently to be described, being situated from one-quarter to one-third of an inch only above them. A series of singularly interrupted and overlapping wave lines, obviously the remains of the parallel or zigzag, furrow-edges of the second variety above described, plainly enough show that they were produced by ripple action, through a gentle current of water setting transversely across the furrow-ridges.

The third kind of impressions is considerably different from either of the foregoing, and requires a more particular description. The hexagons are disposed in long, nearly straight, parallel series, though now and then a row suddenly runs out where it abuts directly against a furrow-ridge; or in other words a ridge is seen to bifurcate, or to be replaced by a furrow. The cavities in this variety have nearly double the breadth or area of the two first varieties. In hexagons of the third variety the two opposite sides that are at right angles to the furrows have treble the length of the other two pairs, which seemingly have been shortened at their expense. The angles of the hexagon also are not equal. The four situated at the extremities of the longer sides, are less than 110°, while the two remaining (transversely opposite) ones are over 130°. The four shorter edges moreover are often flattened down into a broad band, while the long transverse ridges remain thin and sharp, though not straight at top, but gently arcuated. Indeed they are sometimes so low and faint as to become almost obsolete, thus changing the row of cells almost into a trough, whose borders are composed of the shorter zigzag sides of contiguous hexagons (under angles of 130°);—the whole seeming to have originated in a contraction of these sides, and a corresponding elongation of those at right angles to the furrow. The flattened band is not perfectly horizontal, but inclines a little toward the bottom of the trough, and constantly in one direction throughout the series,—its lower side being situated upon the upper or most shallow side of the hexagonal cell or cavity, or in other words the greatest depression in the furrow adjoins the superior edge of the band—it being kept in mind that the greatest concavity in the cells is never central but always somewhat marginal. In some of the slabs the furrow-edges are much less deeply truncated, rarely they are flatly

bevelled; and in one case for a little distance, I have seen them replaced by four narrow planes. But the most singular feature of those specimens with a single broad band, consists in the presence upon it of a circular scar, which is uniformly located between the large angle of 130° and the adjoining smaller one of 110°, just in one corner of the impression, and always in the same corner relatively, throughout the series. Its diameter is about one-fifth of an inch, and it would appear to have arisen from the presence of some adhesive matter at these points which has operated to interfere with the usually easy cleavage of the shale, whereby several layers of it have remained adhering together, producing either a depression or an elevation upon it, according as the scar is found on one side or the other of the separated shale. In addition to the foregoing, the tripartite brush is seen radiating directly from the scar, obliquely into and nearly across the bottom of the contiguous depression, pointing as it were to the scar on the contiguous band.

It should further be mentioned that the repetitions of these impressions of each separate sort are very numerous, and each equally smooth, sharp and perfect, through a thickness of from one-third to half an inch, and in every instance where overlapped by a different variety, the parallelism of the rows is very obvious.

The difficulties in the way of the tadpole theory early induced me to question it as explaining the above appearances; and I was led to seek other modes of accounting for the phenomena more in harmony with the facts. For a time, at the suggestion of a very eminent authority in comparative anatomy, I endeavored to find an explanation in the supposition that they proceeded from the spawn of gigantic batrachians, whose footprints at neighboring localities are so common in shale of the same formation. But such an origin, besides other incompatibilities, required an organized association of the ova into a flat tier or mat, made up of parallel rows (one egg in depth), for rods in length and many feet in width. No reptilian germs are known to be extruded in such a shape. My next conception was, that the imprints may have owed their origin to a gigantic species of alga, allied to the *Hydrodictyon utriculatum*, though constituting a different genus, and possibly pertaining to a different family altogether, of these fresh-water plants.

A recent mineralogical visit to the granite quarries of Rockport at Cape Ann, by bringing under my inspection a very remarkable exhibition of ripple-marks upon the sea-shore, leads me to refer the South Hadley imprint to a similar cause. The recent ripple-marks occur in a very striking manner almost directly in rear of the Sandy Beach Hotel, in a somewhat sheltered place at the head of a little bay or cove, where the

sand is fine and the bottom hard. A gently swelling, elongated bar, six or eight rods in length, running parallel with the shore is here found. Its breadth is about half its length, and its elevation where the highest, twelve or fifteen inches above the narrow flat creek-bottom between it and the shore. The breadth of this interval does not exceed ten or fifteen feet, the middle half of which is nearly flat, while the sides therefrom slope upward very gradually each way. The bar is left bare at about half tide. The water flows in and out of the creeklet at both ends of the bar, and when the tide is sufficiently high, flows back and forth cross-wise, to the bed of the creek. During the rising of the tide, the bed of this elongated depression is more or less covered with water for nearly an hour before the bar is wholly submerged. Throughout this period, as well as at all other times while accessible, and best of all, at low water, when the surface is left wholly bare, an almost perfect repetition of the second and third varieties of the South Hadley impressions is every where visible, though the size of the cavities is constantly from two to threefold that of the fossil specimens. With singular precision may be seen the parallelism of the furrows (corresponding with the sea-margin), the cross partitions (though generally more faint than in the shale), the zigzag margins formed by those sides of the cells which give rise to the furrow-ridges, the frequent splitting of a ridge so as to form an additional (an interpolated) furrow, the smoothing down of a ridge so far as to produce the flat band, and the almost constant occurrence of the deepest part of the trough on the down-hill side of the furrow. Other coincidences might be pointed out with the aid of drawings; but the foregoing are perhaps sufficient for our purpose. The appearances remained in full view during several days of calm weather, the pattern being only slightly interfered with, during the ebbing and flowing of the tide. At low water the configuration of the surface was invariable.

The examination of these sea-shore markings led me to recur to a large sandstone slab (with a surface two feet square) procured two years ago from the Forrest-marble Oolite of Wiltshire, England, on account of its crustacean foot-prints. Here also we are presented with ripple-marks of the same regularity as on the Rockport beach. In area, the cavities are just half way between those from the sea-shore and those from the New Red Sandstone. The zigzag lines of the furrow-ridges, the position and distinctness of the transverse partitions, the greater depth of the cavities constantly toward one side rather than in the middle of the furrows, and the occasional bifurcation of the ridges, so as to embrace an additional trough are all plainly conspicuous. This specimen taken along with the Rockport sea-shore ripples leave no remaining doubt in my mind that the ori-

gin of the appearances in all three of the cases is ascribable to the same cause: viz., to a wave-like, vertical motion produced by the air on the surface of nearly still water, combined with feeble horizontal currents (acting in directions nearly at right angles to each other) upon the bottom.

Amherst College, Oct. 15, 1866.

ART. XV.—*On a Theory proposed by Fresnel, and on a mode of measuring the average size of very fine particles;* by OGDEN N. ROOD, Prof. of Physics in Columbia College.

IF the light from a candle-flame be received on a ground glass surface, so obliquely that the incident ray makes only a very small angle with the glass surface, the light will be copiously reflected, and a bright uncolored image of the flame will be seen by reflexion. As the angle made by the incident ray is increased, the reflected image becomes first yellow, then red, and finally disappears altogether.

Fresnel has attempted to account* for this fact, on the ground that the more refrangible rays, having shorter wave-lengths, are caused to interfere by a difference of path, which is still too small to effect complete interference in the case of the longer waves of red light; the difference in path, depending on the depth of the minute scratches on the surface of the glass, and on the angle which the ray makes with this surface.

As it is not difficult to measure approximately the angle at which the red ray ceases to be reflected, it would be easy to put this theory to the test of experiment, if the average depth of the scratches on the ground surface were known.

The impossibility of obtaining such measurements, has hitherto prevented this theory of the action of finely roughened surfaces on light, from being either confirmed or overthrown.

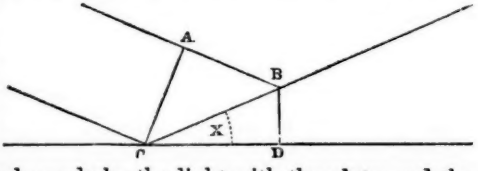
Some time ago, while experimenting on a plane polished surface of glass which had been smoked with lamp-black to complete opacity, I was surprised to find that the lamp-black surface, at a great obliquity, reflected all the rays of light with much brilliancy, so that it resembled in appearance a polished surface of metal or glass. With less degrees of obliquity the reflected light was yellow, red, and finally disappeared altogether.

The lamp-black surface in this experiment was obtained from burning paraffine, and it was found that the red ray ceased to be reflected at an angle of 18°, reckoning from the glass surface. The source of light was a small gas-flame and the experiments

* Pogg. Annalen, Bd. xii, p. 210.

were made in a darkened room at night, the glass plate with its lamp-black surface, being attached to the axis of a graduated circle, the lamp-black having been removed from the upper half of the plate, so as to allow the proper adjustments to be made with the aid of the naked glass surface. I then attempted to measure with the microscope the average size of the smaller and more numerous particles of lamp-black; the result obtained was that they varied in size from ·000018 to ·000012 of an inch. Several months *afterwards*, I made a calculation to ascertain what the difference in the path of the interfering rays would be, using these data, and what relation this difference bore to the length of a wave of red light.

Assuming the dimensions of the particles of lamp-black to be the same in all directions, we have the annexed construction. BD will represent the diameter of a particle of lamp-black, the ray AB is reflected from its surface, the ray CB from the layer next below; X is the angle made by the light with the plate, and the difference in path of the two rays will evidently be equal to CB −AB, a quantity readily found by calculation.



Taking the size of the lamp-black particles to be equal to ·000018 of an inch, the difference in path of the two rays for an angle of incidence of 18° is ·000011, while the wave-length of the line C in the red space is nearly ·000026 of an inch. This shows that the difference in the path is not far from half a wave-length of red light, if the larger of the two estimates of the size of the particles of lamp-black is employed.

I then made a new set of experiments relative to the angle at which the red ray disappears, using as before lamp-black from paraffine. This was found to vary somewhat in different portions of the same plate, as is seen in the table below.

21°, 20°·75, 18°·75, 20°, 20° = 20°·1

New microscopic measurements on the size of the lamp-black particles were made with a different microscope, the value of the micrometer not being known; it was estimated that the size of the smaller and more numerous particles varied from $\frac{1}{43000}$ to $\frac{1}{60000}$ of an inch, but that there were more particles approaching the first number than the second, a circumstance of which I have not taken any advantage in the following calculation.

Taking the mean of these determinations, and combining it with the mean of the first determination, we obtain for the mean size of the particles $\frac{1}{68434}$ = ·0000146 of an inch.

The average angle of disappearance of the red ray being 20°, there results a difference of path =·0000998; that is, the difference of path is to the wave-length of red light nearly as 10 to 26.

When the difficulty of obtaining an approximate measurement of the size of the particles of lamp-black is considered, it is surprising to see how nearly the calculated difference in path approximates to half a wave-length of the light in question.

I found that a surface of magnesia produced by smoking a glass plate to opacity with burning magnesium wire, also reflected light in the same way at very oblique incidences. It was ascertained that the final tint was red, and that the red rays themselves disappeared at 11°. The size of the particles of magnesia was estimated at ·000036. Long after the measurements had been obtained I calculated the difference of path for the interfering rays; this was found to be,

	·000014
wave-length of C	·000026

giving a still nearer approximation to a difference of $\frac{1}{2}$ a wave-length.

These experiments then seem to point out the correctness of Fresnel's theory, and we should I think be justified in reversing the process, and using the angle of disappearance of the red ray, in connexion with the known wave-length of this ray, for the purpose of calculating the average size of small particles or the average depth of fine scratches or furrows.

I give below the calculated values of the average size of the particles of lamp-black and magnesia.

Lamp-black from paraffine,	·0000188 calculated.
" " "	·0000146 measured.
Size of particles of magnesia,	·0000338 calculated.
" " "	·0000361 measured.

Some experiments were made on the angle of disappearance of the red ray with lamp-black produced by the burning of different substances; where the figures are connected by a bracket it is intended to indicate that the two angles were obtained from the same portion of the plate.

Lamp-black from stearine.	Lamp-black from camphor.	Lamp-black from a solution of spirits of turpentine in alcohol.
18°·25	16°	22°
18 ·75	15 ·9	21
16	15 ·1	20
16	15 ·4	
17°·25	15°·6	21°

It would appear from these last experiments that the average size of the particles of lamp-black from burning camphor is somewhat greater than from paraffine, while in the case of "burning-fluid" the particles are smaller.

New York, Dec. 4th, 1866.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On a new form of magneto-electric machine.*—When the armatures of an ordinary magneto-electric machine with permanent steel magnets are wound with coarse wire, currents of electricity are obtained which are capable of developing magnetism in an electro-magnet. It is easy to see that the magnetism thus developed may in its turn be made to generate a current of electricity, and that this again may induce magnetism in a second and larger electro-magnet, and so on alternately. Mr. H. Wilde has availed himself of this principle to construct magneto-electric machines of extraordinary power. As the author's descriptions are not very clear, even with the aid of figures, we shall content ourselves with giving the general construction of the apparatus and the results obtained with a particular machine. In this machine the generator or primary source of the electric current was a magneto-electric machine consisting of six small permanent magnets weighing only one pound each and capable of lifting collectively a weight of, at most, 60 lbs. The current from this excites an electro-magnet weighing three tons, the total weight being about four and a half tons. The armatures are driven at a uniform velocity of 1500 revolutions per minute by means of a steam-engine and a very strong leather belt. With this machine pieces of iron rod fifteen inches in length and one-fourth of an inch in diameter were melted. With an intensity armature a light was obtained between points of gas carbon sufficiently intense to cast shadows from the flames of street lamps at a distance of a quarter of a mile. It is easy to see that by passing the current derived from the electro-magnet through another and larger electro-magnet a vast increase of electric force could be obtained, of course at the expense of a greatly increased motive power. With an unlimited increase of motive power an unlimited increase of electric force could be obtained, as in fact the whole machine is to be regarded as a means for transforming heat into mechanical power, and this last into electricity. It is to be regretted that the author has given no precise data from which the amount of electricity set free can be determined with precision. The quantity of water decomposed per minute, with the expenditure of a measured amount of mechanical work, is what we require in order to form a correct estimate of the value of the apparatus, as compared with that of other electro-motors. In any case, however, it is safe to predict a brilliant and useful future for the new apparatus.—*Proc. of Royal Society*, xv, 107. W. G.

2. *On the synthesis of chlorid of thioxyl.*—Wurtz has made the very interesting observation that chlorid of thioxyl, $S_2O_2Cl_2$ or $S\overline{O}Cl_2$, may be produced by the direct union of anhydrous hypochlorous acid with sulphur, $Cl_2\overline{O}+S=S\overline{O}Cl_2$.

The vapor of hypochlorous acid is passed into chlorid of sulphur holding sulphur in suspension, and the operation is discontinued as soon as the sulphur has entirely disappeared. The chlorid of thioxyl may then be separated from the chlorid of sulphur by distillation. Chlorid of thioxyl

as thus prepared is a colorless liquid which has a penetrating odor reminding of sulphurous acid and chlorid of sulphur. Its density at 0° is 1·675, and its boiling point 78° at 746 mm. Water resolves it into chlorhydric and sulphurous acids, $S\Theta Cl_2 + H_2\Theta = 2HCl + S\Theta_2$.

Liquid hypochlorous acid explodes on contact with sulphur, and it is for this reason that the action must be moderated by suspending the sulphur in chlorid of sulphur and keeping this at a temperature of −12° C. From the above it is clear that $Cl_2\Theta$ may unite directly with a radical, a fact which stands related to the observation of Carius that $HCl\Theta$ unites directly with certain hydrocarbons.—*Comptes Rendus*, lxii, 460.

W. G.

3. *On a new series of hydrocarbons.*—Schorlemmer has discovered among the products of the distillation of cannel coal, besides the homologues of marsh gas and benzol, other hydrocarbons attacked by concentrated sulphuric acid. When the oil, after treatment with the acid, is distilled, the oils of the benzol and marsh gas series pass over first and there remains a black tarry mass. If this mass be distilled, a thick brown liquid with an offensive smell passes over between 300° and 400°. By repeated distillations with caustic alkali and with sodium a series of carburets may be obtained with the general formula $(C_nH_{2n-2})_2$; of these the author describes $C_{12}H_{20}$, $C_{14}H_{24}$, $C_{16}H_{28}$. These are all colorless oily highly refractive liquids, having a faint peculiar smell resembling that of the carrot or parsnip root. These oils unite with bromine to form colorless heavy liquids easily decomposed by heating. A molecule of oil takes up two atoms of bromine. Strong nitric acid dissolves the oils, forming nitro-compounds which with tin and chlorhydric acid give organic bases. With sulphuric acid and bichromate of potash the oils yield carbonic, formic, acetic, and perhaps other acids. The author considers it certain that the oils of this series are polymers of the acetylene series.—*Annalen der Chemie und Pharm.*, cxxxix, 244. W. G.

4. *On the compounds of tantalum.*—Marignac has published the conclusion of his researches on niobium and tantalum, the first part of which has already been noticed in this Journal. To determine the atomic weight of tantalum, pure crystallized fluotantalate of potassium, $KF.TaF_5$, was treated with concentrated sulphuric acid and carried finally to a temperature of 400° C. On boiling with water, bisulphate of potash is dissolved out and sulphate of tantalum left in small granular crystals, which by strong ignition yield tantalic acid. The bisulphate of potash is brought by evaporation and ignition to the state of sulphate and weighed as such. Four analyses closely agreeing with each other gave the number 182·3 as the atomic weight of tantalum; a molecule of tantalic acid has therefore the formula $Ta_2\Theta_5$, and the molecular weight 444·6. The analysis of the fluotantalate of ammonium leads to the number 182 as the atomic weight of tantalum, and this number is adopted by Marignac as most probable. The author remarks that the difference between the atomic weights of niobium and tantalum, which belong to the same natural family, is the same as that between the atomic weights of the closely allied metals, tungsten and molybdenum, namely, 88. Tantalic acid forms two classes of salts, in one of which it is monobasic and in the other quadribasic. The first class have the formula

$Ta_2\Theta_5.M\Theta$, and the second the formula $3Ta_2\Theta_5.4M\Theta$: the tantalates of soda and potash belong to this last type and crystallize well. The oxyd and sulphid of tantalum described by Berzelius and others have respectively the formulas $Ta\Theta_2$ and TaS_2. Chlorid of tantalum has the formula $TnCl_5$; the calculated density of its vapor is 12·84, while Deville and Troost find 12·42. Tantalic acid not ignited dissolves easily in fluohydric acid and forms soluble and crystallizable salts with other fluorids, but it does not appear that there is a class of oxyfluotantalates corresponding to the oxyfluoniobates. The fluotantalate of potassium, $TaF_5.2KF$, crystallizes in the right rhombic system and is isomorphous with the corresponding fluoniobate. When boiled for a long time with water the salt changes to an insoluble body having approximately the formula $Ta_2\Theta_5+2(2KF.TaF_5)$, which may, however, be only a mixture. The formation of this insoluble compound gives the means of detecting the smallest quantity of fluotantalate in the oxyfluoniobate of potassium. Two fluotantalates of sodium have respectively the formulas $TaF_5, 2NaF+H_2\Theta$ and $TaF_5 3NaF$. The other salts described are $TaF_5, 2NH_4F$, $TaF_5, 2ZnF+7aq.$, and $TaF_5, 2CuF+4aq$. In our first notice of Marignac's researches we have stated that that chemist had detected in niobite a small quantity of an acid which might prove to be new. Further investigation has, however, shown that this is titanic acid.—*Bull. de la Soc. Chimique*, Aug. 1866, pp. 118 and 115. W. G.

5. *On the preparation of iodhydric and phosphoric acids.*—Pettenkofer has given a very elegant modification of Liebig's process for the preparation of iodhydric acid and alkaline iodids, and has further extended the method so as to obtain pure phosphoric acid as a subsidiary product. To half an ounce of common phosphorus in twelve ounces of distilled water at 60° or 70° C. one ounce of iodine out of eight ounces is to be added. The whole is to be stirred and the liquid poured off from the phosphorus and iodid of phosphorus upon the remaining seven ounces of iodine contained in a separate vessel. The solution of iodine as thus obtained is to be poured back upon the phosphorus and the alternate process repeated until all the iodine is dissolved and has come in contact with the phosphorus. The red-brown liquid last obtained becomes almost colorless after a short time, and there remains only a little red phosphorus. The filtered liquid, consisting of water, iodhydric, phosphorous and a little phosphoric acid, is to be distilled over an open fire till the liquid becomes syrupy. The distillate consists of iodhydric acid containing a little free iodine, and has a specific gravity of 1·39 to 1·40. It appears to keep well and serves for the convenient preparation of the iodids of potassium, sodium, calcium, &c. Saturated with bicarbonate of potash the acid yields on evaporation and crystallization a pure iodid in perfectly colorless crystals. The contents of the retort are to be poured out, the retort washed, and a few drops of concentrated nitric acid containing nitrous acid added, when the whole remaining iodhydric acid is decomposed into water and free iodine. The free iodine may be separated by filtration, after which the filtrate is warmed till it becomes colorless. The filtrate is then to be evaporated with about one and a half ounces of nitric acid of 1·20, added in small portions at a time until, on addition of pure acid, nitrous acid fumes are no longer evolved. The so-

lution of phosphoric acid is then to be evaporated till the vapor arising no longer reddens litmus. In this manner a pure phosphoric acid, free from arsenic and sulphur, was obtained, although the phosphorus employed contained traces of both substances.—*Ann. der Chemie und Pharm.*, cxxxviii, 57. W. G.

6. *On crotonic acid.*—Bulk has given another instance of the conversion of one organic acid into another by simple addition of one molecule or two atoms of hydrogen. When crotonic acid, $\mathrm{C_8H_6O_2}$, is heated with an amalgam of sodium or with metallic zinc and dilute sulphuric acid, it passes gradually into butyric acid, $\mathrm{C_4H_8O_2}$, this last being in the modification in which it is obtained by fermentation.—*Ann. der Chemie u. Pharm.*, cxxxix, 62. W. G.

7. *On syntheses of guanidin.*—A. W. Hofmann has succeeded in the synthesis of guanidin, $\mathrm{N_3}\left\{\begin{matrix}\overset{\text{IV}}{\mathrm{C}}\\ \mathrm{H_3}\\ \mathrm{H_2}\end{matrix}\right.$, by two different processes. An alcoholic solution of chlorpicrin, $\mathrm{C(NO_2)Cl_3}$, and ammonia is heated for some time in a closed tube to a temperature of 100°. Under these circumstances the reaction occurs which is represented by the equation

$$\mathrm{C(NO_2)Cl_3+3NH_3=CH_5N_3,HCl+2HCl+HNO_2}.$$

When orthocarbonic ether is heated to 150° C. with aqueous ammonia, guanidin and alcohol are formed, according to the equation,

$$\mathrm{C(C_2H_5)_4O_4+3NH_3+H_2O=CH_5N_3,H_2O+4(C_2H_5,HO)}.$$

The author suggests that the corresponding orthosilicate of ethyl, $\mathrm{Si(C_2H_5)_4O_4}$, may by a similar process yield a species of guanidin in which silicon takes the place of carbon, and also that the well known compounds formed by the action of ammonia upon the chlorids of silicon and titanium may be simply mixtures of sal-ammoniac with the chlorhydrates of guanidin containing silicon or titanium in place of carbon.—*Ann. der Chem. u. Pharm.*, cxxxix, 107. W. G.

8. *On flame reactions.*—Bunsen has made a systematic study of the action of different parts of the flame of the well known burner which bears his name, on various substances, either alone or mixed with fluxes and other reagents. As no mere abstract can do justice to a paper of this character we must refer our readers to the original. It can hardly be doubted that, wherever gas can be had, the flame of the burner will soon supplant the ordinary mouth blowpipe in testing upon a small scale by heat.—*Ann. der Chem. u. Pharm.*, cxxxviii, 257. W. G.

II. MINERALOGY AND GEOLOGY.

1. *Geological Survey of Illinois;* A. H. Worthen, Director. Volume I, *Geology*. xvi, and 504 pp. royal 8vo, with map, sections, &c. 1866, Springfield. Published by authority of the Legislature of Illinois.—In the September number of this Journal, we gave a brief notice of the issue of this valuable Report, it having reached us so near our publication day, that we were unable to do more than merely acknowledge its reception, and promise a more extended notice in a future number. Circumstances beyond our control prevented the preparation of this notice in

time for the November number, but we now propose to fulfil the promise, so far as limited space will permit.

As stated above, this Report occupies about 520 pages of letter-press, and is printed in large clear type, upon excellent paper, with well executed illustrations; and the whole is neatly and substantially bound in cloth. Chapter I consists of remarks on the General Principles of geological science,—the physical features of the State, its Surface geology, &c. In Chapter II the Tertiary deposits and the Coal-measures are described and their relations to the other formations of the state explained, by a section showing the thickness, order of succession, &c., of the various rocks occurring in Illinois. The Tertiary, consisting of various colored clays, greenish sand, &c., occupies but a limited area in the southern part of the state, and has yet afforded only a few imperfect casts of fossils, apparently of Eocene age.

The Coal-measures being of great economical importance, are described at length, and numerous sections of their various beds are given, as ascertained from natural exposures, borings, shafts, &c. Contrary to an opinion somewhat current among geologists, the State Geologist maintains that the Illinois coal-field is not broken up into several isolated patches, separated by intervals of older rocks, but is a continuous field, occupying near three-fourths of the entire area of the State. The maximum thickness of the whole series, exclusive of the Millstone grit, is, in the southern part of the State, about 900 feet, including six workable beds of coal, with an aggregate thickness of 30 feet. Going northward, the Coal-measures diminish in thickness, chiefly by the thinning out of lower beds, so that on the northern borders of the field, where the Millstone grit and Subcarboniferous rocks are wanting, some of the higher members are found resting directly down upon Devonian and Silurian rocks: thus apparently showing that as far back at least as the commencement of the Subcarboniferous period, the northern part of the state was more elevated than the southern, and that as the subsidence of the whole area progressed, the successive newer beds extended farther and farther northward. The whole series being, with one or two local exceptions, almost entirely undisturbed by upheavals, flexures, faults, &c., the miner meets with few of the obstacles here, that so materially diminish the profits of coal mining in more disturbed districts. From the facts given, it is evident that we can scarcely overestimate the value and importance of this inexhaustible store of mineral wealth, as a source of power and progress, to a state like Illinois, which also has a vast extent of the most beautiful undulating prairie lands unsurpassed in productiveness and easily brought under cultivation.

In regard to petroleum in Illinois, the State Geologist remarks that it has been found in small quantities in two or three of the southern counties; and that from the greater thickness, on the eastern borders of the State, of the rocks generally regarded as the source of the oil deposits in western Pennsylvania and eastern Ohio and Kentucky, it will be most apt to be found in paying quantities in the region of the Wabash valley. The correctness of this suggestion has been confirmed since the printing of the Report, by a valuable flowing well sunk at Terre Haute, Indiana.

In Chapter III, the various Subcarboniferous rocks are fully described in the order of their succession from above, and various analyses by the late Henry Pratten, Esq., showing their chemical composition are given. The thickness, geographical range, general physical characters, characteristic fossils, &c., of each of these rocks are also stated in considerable detail. This chapter likewise includes an interesting Report by Prof. G. J. Brush of Yale College, on the geodes so abundant at the Rapids of the Mississippi in the Keokuk beds.

The Devonian and Silurian rocks are similarly treated of in chapter IV; while in chapter V, we have a valuable and highly interesting Report on the Galena Lead region, by Prof. J. D. Whitney, now the State Geologist of California. Prof. Whitney's Report is illustrated by a large, neatly engraved and colored map of the Lead region, on which the boundaries of the several formations, the position and bearings of lead crevices, and the general topography of the country are accurately laid down. It also contains another map on a larger scale, of the country around Galena, on which similar information is given in more detail: likewise a columnar section showing the various rocks that occur in the lead district, their thickness, composition, order of superposition, &c. As it would be impossible in a notice like this, to give an intelligible idea of the amount of statistical and scientific information contained in this Report, respecting the mode of occurrence of the ore, the methods pursued in extracting it, the processes of smelting, the yield of lead, &c., we must refer the reader to the Report itself for such details.

Chapter VI is composed of a Report by Prof. Leo Lesquereux, on the Coal fields of Illinois, giving a large amount of information respecting the structure of the Illinois Coal series, and the relations of its various beds and outcrops to each other, and to those of Kentucky, Arkansas, Indiana, Ohio and Pennsylvania, as determined by a careful study of the fossil plants found associated with each of these beds. From the long experience this gentleman has had in exploring the Coal-measures of the West, and his extensive knowledge of fossil Botany, it may be readily inferred that this chapter will be found full of interesting and practical information. In Chapter VII, he likewise discusses at length the mooted question respecting the origin and formation of prairies, which he thinks are due to the gradual disappearance of marshes.

The chemical Report of Dr. J. V. Z. Blany, chemist of the survey, constitutes Chapter VIII. This Report contains much valuable information, consisting of numerous analyses of coals, iron ores, &c., chiefly the former, with classifications and descriptions of the same.

The remaining portions of the volume consists of detailed county Reports as follows:—On Randolph county, St. Clair county, Madison county, Hancock county, and Hardin county, by the State Geologist. The Report on the latter county is illustrated by a neat colored map, and also includes an interesting Report on the Rosiclare Lead mines, illustrated by diagrams, plans of the different workings, &c., by Prof. J. G. Norwood of the University of Missouri. The following counties are reported upon by Mr. Henry Engelmann, viz:—Johnson, Pulaski, Massac and Pope. These county Reports are all in great detail, and contain a large amount of practical and scientific information.

At the end of the volume, there is a copious glossary of scientific terms, followed by the index, and a neatly engraved section of the rocks seen along the Mississippi from the northern boundary of the State to Cairo.

This volume shows throughout that the survey of the State, so rich in resources, has been in the hands of an able and successful geologist. We earnestly hope that the Legislature may make the necessary appropriation this winter for a third volume, which we are informed the State geologist has in a forward state of preparation, including detailed reports of many county surveys, and other valuable information; and that nothing may prevent the onward progress of the survey to its final completion, and the publication of all the results. The publication of such reports not only advances the material interests of a State, by spreading useful information among the people, but by inviting capital, enterprise and emigration from other parts of our own country and from abroad.

2. *Contributions to the Paleontology of Illinois and other Western States;* by F. B. MEEK and A. H. WORTHEN, of the Illinois State Geological Survey. (Proceed. Acad. Nat. Sci. Philad., July, 1866, p. 251.)—This paper contains descriptions of the following new species and genera of fossils from the Carboniferous rocks of the West:—*Belemnocrinus Whitii*, *Synbathocrinus Wachsmuthi* (type of a new subgenus *Nematocrinus*), *Cyathocrinus Farleyi*, *Rhodocrinus nanus*, *Onychocrinus diversus*, *Granatocrinus Shumardi*, *Schœnaster Wachsmuthi*, *Pteria* (*Pterinea?*) *Morganensis*, *Macrodon micronema*, *Platyceras lævigatum*, *Platyceras haliotoides*, *P. uncum*, *P.* (*Orthonychia*) *Chesterensis*, *P.* (*O.*) *subplicatum*, *P.* (*O.*) *infundibulum* (=*P. subrectum* Hall, 1860; not *P. subrectum* of the same author, 1859), *Metoptoma* (*Platyceras?*) *umbella*, *Polyphemopsis Chesterensis*, *Anomphalus rotulus* (type of a new genus allied to *Rotella*), *Microdoma conica* (type of a new genus), *Orthonema conica*, *Trochita? carbonaria*, *Pleurotomaria conoides*, *P. Coxana*, *P. spironema*, *P. valvatiformis*, *Murisonia inornata*, and *Nautilus* (*Cryptoceras*) *Rockfordensis*.

It also contains notices of two new genera of Crinoids, which are more fully described and illustrated in the second volume of the Illinois report. The first of these genera, *Strotocrinus*, is proposed for those greatly expanded species, such as *Actinocrinus perumbrosus*, *A. regalis*, &c., of Hall. Prof. Hall had proposed for this type the name *Calathocrinus*, which could not stand because von Meyer had previously applied it to another group in 1848. The other genus, *Steganocrinus*, is proposed for a curious group, of which *Actinocrinus pentagonus* of Hall is the type. This type differs from *Actinocrinus*, in having the rays, when found entire, greatly extended out horizontally in the form of slender, free, rigid arm-like appendages, covered all the way out by small pieces like the vault, and bearing the true arms along their lateral margins.

The authors likewise make some remarks on *Onychocrinus* of Lyon & Casseday, which they think most probably a good genus, though it has generally been regarded as a synonym of *Forbesiocrinus;* also on the genus *Platyceras* Conrad, which they think more nearly allied to the recent genus *Capulus*, than has been supposed in this country, though still generically distinct.

Most of these fossils, and others previously described by the same authors, will be fully illustrated and more elaborately described in a future Report of the Illinois Survey.

3. *A Geological and Agricultural Survey of* 100 *miles west of Omaha;* by the American Bureau of Mines.* New York, 1866, 44 pp., 8vo.—This Report embodies the results of a reconnoissance made during the past summer by Prof. Thos. Egleston, along the line of the first hundred miles of the Union Pacific Railroad, west of Omaha, Nebraska. The survey was made under a commission from the railroad company, the chief object being probably to throw some light upon the question of the probabilities of finding workable beds of coal in that region, within accessible distances beneath the surface.

When it is remembered that the publications of previous explorers had made the general features of the geology of that part of the country so well known as to prevent the possibility of new and startling discoveries, it must be conceded that Prof. Egleston has made up quite an interesting report upon the physical features of the district explored—its agricultural capacities, climatology,† &c. He has also accurately described the Upper Carboniferous, Cretaceous, Drift, and alluvial formations previously known to exist there. From the Carboniferous beds he collected some thirty-five species of fossils, one of which (*Nautilus Illinoiensis*) had not, we believe, been before discovered at the localities mentioned. These fossils were identified by Mr. Meek,‡ and a list of them is given on pages 12 and 13 of the Report.

In regard to coal, Prof. Egleston thinks, from what is known respecting the structure of the Coal formation in northern Missouri and western Iowa, that workable beds may possibly be struck at a depth of 550 feet below the surface of the Missouri at Omaha, and at near 600 feet below the same horizon at Bellevue.

4. *Notes on the Geology of Western S. America;* by A. Rémond, (from a letter to Prof. W. H. Brewer, dated Santiago, Chili, Oct. 11, 1866).—The following are among the discoveries which I have made on the west coast of South America.

(1.) Jurassic fossils in the metamorphic rocks about Lima; some of the species strongly resemble those found in the belt of the same age in California.

(2.) At the Morro of Arica, lat. 18° 28′ S. on the coast of southern Peru, Jurassic species, one of them identical with fossils found by Dr. Philippi near Chaco, east of the Desert of Atacama, lat. 25° 12′ S.

(3.) A collection of fossil plants, probably of Triassic age, from the coal-bearing formation of northern Chili, a region previously unexplored by geologists. Some of these species are similar to those I brought from

* It should be here noted that the American Bureau of Mines is a private association, and not a government institution.

† The Smithsonian Institution's publications are credited for the meteorological data upon which the remarks on the climate are based.

‡ Our attention has been called by Mr. Meek to quite a number of typographical errors in this list of fossils, for which he is not responsible, as the list was not printed from a manuscript written by him, and he saw no proof of it as the Report went through the press.

Sonora two years ago; and two of the species, a Pecopteris and a Pterophyllum, are probably identical.

(4.) At the silver mines of Tres Puntas and Chanarçillo, species of lower Cretaceous; and above the coal beds many species of Lias, but most of them have been found before by Prof. Domeyko at Las Juntas and Tres Cruces.

(5.) Eocene fossils at Caldera, lat 27° 4′. Near this port are also extensive beds of recent shells well preserved.

(6.) Near Coquimbo many species from the middle and upper Tertiary.

5. *Carta Geologica di Savoja, Piemonte e Liguria;* del commendatore Angelo Sismonda, Professore di Mineralogia nella Universita di Torino, etc. 26×31 inches, colored. Published by the Italian government.—This geological chart, by Prof. Sismonda of Turin, gives, in colors, the geology of perhaps the most interesting part of Europe. It covers northwestern Italy, west of Cremona and Milan, and extends north, across the Alps, to Lake Geneva and the Rhone. It hence exhibits the rock formations of Italy stretching north over the regions of the southern Alps. Thus we observe, among its many points of great interest, the region of crystalline rocks (protogine, gneiss, mica schist, etc.) in which stands Mt. Blanc, lying *within*, and trending with, the great Jurassic belt that divides Italy and France; this Jurassic formation to the westward of Mt. Blanc being mostly unaltered, while that on the east is metamorphic. The difficult geological problem of the Alps receives a large part of its solution from the facts observed in northern Italy.

6. *Comptoir Minéralogique of F. Pisani at Paris.*—Mr. Pisani has opened rooms for the sale of minerals in the same court recently occupied by the late Louis Sæmann, No. 6 Rue de Mézières. He is an excellent mineralogist as well as chemist, and many difficult points in mineralogy have been elucidated by his analyses. We take pleasure in commending his establishment to all who desire to procure minerals either by the specimen or cabinet.

7. *Discovery of additional Mastodon remains at Cohoes, N. Y.*—A few weeks after the discovery at Cohoes of the lower jaw of a mastodon, a notice of which appeared in the last number of the Journal (p. 426), some additional remains were found in the same locality; and subsequently the skull and many other parts of the same skeleton were brought to light. These also are in an excellent state of preservation, and the whole, when seen together, exhibit admirably the prominent characters of the species, as well as some structural peculiarities of much scientific interest.

The remains are evidently those of the common North American mastodon—*M. Ohioticus* (*M. giganteus* Cuvier). The imperfect ossification of some parts of the skeleton, especially the epiphyses, shows that the animal was comparatively young, while the absence of tusks from the lower jaw would indicate a full-grown female.

The missing portions of the skeleton are without doubt in the same pot-hole, which contained those already found, and, although their recovery may involve considerable expense, it is greatly to be hoped that all may be secured; as the skeleton would then be one of the most perfect ever discovered, and prove a most important addition to the New York

State collection, in which, through the generosity of the Harmony Mills Co. of Cohoes, it is to be permanently deposited.

The pit, in which the mastodon remains were found, had evidently been formed by several pot-holes wearing into each other. It was about forty feet in diameter at the top, and forty in depth; and was filled chiefly with decayed vegetable matter, resembling peat, in which were imbedded many fragments of trees, mostly conifers. The arrangement of the materials showed that they had been deposited rapidly, and a part of a beaver dam, found near the bottom, would indicate that the whole had been swept in by a freshet. No other animal remains were found except those already mentioned, although the "beaver-sticks" probably indicate one cotemporary of the mastodon.

Some of the specimens of wood found with the skeleton, and evidently introduced at the same time, were sufficiently well preserved to admit of determination. Among these were noticed species of the white pine (*Pinus strobus* L.), the common hemlock (*Abies Canadensis* Michx.), the black spruce (*Abies nigra* Poir.), the American larch (*Larix Americana* Michx.), the swamp maple (*Acer rubrum* L.), and the white birch (*Betula alba* Spach.) O. C. M.

8. *A Catalogue of Official Reports upon Geological Surveys of the United States and British Provinces.*—In arranging a set of American Geological Reports in the Library of Yale College, the following catalogue became necessary; and it is here published in order that its inaccuracies and deficiencies may be noticed and corrected, while, in its incompleteness, it may be of assistance to some.[1]

PART I.—STATES EAST OF THE MISSISSIPPI RIVER.

MAINE.

1837. *Chas. T. Jackson*, 1st Ann. Rep., Augusta, 12mo, 128 pp. Atlas, 24 pl.
1838. *C. T. Jackson*, 2d Ann. Rep., Augusta, 12mo, 168 pp.
1839. " 3d " " " 276 and lxiv pp.
1837. " 1st " Geol. of Public Lands, Maine and Mass., Boston, 12mo, 47 pp.
1838. *C. T. Jackson*, 2d Ann. Rep., Geol. of Public Lands, Maine and Mass., Boston, 12mo, 93 pp.
1839. *Ezekiel Holmes*, Explor. and Survey of Aroostook River Territory, 1st Ann. Rep., Augusta, 12mo, 78 pp.
1862. *E. Holmes* and *Chas. H. Hitchcock*, Nat. Hist. and Geol., 2d Ann. Rep., Augusta, 8vo, 387 pp.
1863. *E. Holmes* and *C. H. Hitchcock*, Nat. Hist. and Geol., Augusta, 8vo, 447 pp.

NEW HAMPSHIRE.

1841. *C. T. Jackson*, 1st Ann. Rep., Concord, 12mo, 164 pp.
1842. " 2d " " " 8 pp.

[1] Of those Reports marked with an * one copy is needed at the Library of Yale College; and also one copy of any Report not included in the list: persons having them to dispose of are requested to notify the Librarian.

1844. *C. T. Jackson*, Final Rep., Concord, 4to, 379 pp., map, 2 sections.
1845. " Views and Map, illustrating Scenery and Geology, Boston, 4to, 20 pp., 8 pl.

VERMONT.

1845. *Chas. B. Adams*, 1st Ann. Rep., Burlington, 8vo, 92 pp.
1846. " 2d " " " 267 pp.
1847. " 3d " " " 32 pp.
1848.* " 4th " " " 8 pp.
1856. *Augustus Young*, Prelim. Rep. on Nat. Hist., Burlington, 12mo, 88 pp.
1857. *E. Hitchcock*, 1st Ann. Rep., Montpelier, 12mo, 12 pp.
1858. " 2d " Burlington, 12mo, 13 pp.
1861. *Edward Hitchcock, E. Hitchcock, Jr., A. D. Hager*, and *Chas. H. Hitchcock*, Final Rep., Proctorsville, 4to, 2 parts, 988 pp., 38 pl.

MASSACHUSETTS.

1832. *E. Hitchcock*, Final Report (1st Part), Economic Geology, Amherst, 8vo, 71 pp.
1833. *E. Hitchcock*, Final Report (complete), Amherst, 8vo, 700 pp., Atlas, 19 pl.
1835. *E. Hitchcock*, Final Report (2d edition), Amherst, 12mo, 702 pp. Atlas, 19 pl.
1838. *E. Hitchcock*, Rep. on Reëxamination Economic Geol., Boston, 12mo, 139 pp.
1841. *E. Hitchcock*, Final Rep., Amherst, 4to, 831 pp., map and 55 pl.
1853. " Rep. on Surface Geology, Boston, 8vo, 44 pp.
1858. " " Conn. River Sandstone (Ichnology of New England), Boston, 4to, xii and 220 pp., 60 pl.
1865. *E. Hitchcock*, Supplement to Ichnology of New England, Boston, 4to, x and 96 pp., 20 pl.

RHODE ISLAND.

1840. *Chas. T. Jackson*, Final Rep., Providence, 8vo, 312 pp., map, section.

CONNECTICUT.

1837. *Chas. U. Shepard* (Mineralogy and Economic Geol.), New Haven, 8vo, 188 pp.
1842. *Jas. G. Percival*, Final Report, New Haven, 8vo, 495 pp., map.

NEW YORK.

1836. *John A. Dix*, Rep. on proposed Survey, Albany, 8vo, 60 pp.
1837. *John Torrey, James E. DeKay, Lewis C. Beck, Wm. W. Mather, Ebenezer Emmons, Timothy A. Conrad*, and *Lardner Vanuxem*, Ann. Rep., Albany, 8vo, 212 pp.
1838. (*The same, with exception of J. Torrey*, and addition of *Jas. Hall*,) Ann. Rep., Albany, 8vo, 384 pp.
1839. (*The same, with exception of J. E. DeKay*,) Ann. Rep., Albany, 8vo, 351 pp.
1840. (*The same*,) Ann. Rep., Albany, 8vo, 484 pp.

1841. (*The same,*) Ann. Rep., Albany, 8vo, 184 pp.
1842. *L. C. Beck*, Final Rep. Mineralogy, Albany, 4to, 536 pp., 8 pl.
1843. *W. W. Mather*, Final Rep. 1st Dist., Albany, 4to, 653 pp., 46 pl.
1842. *E. Emmons*, Final Rep., 2d Dist., Albany, 4to, 427 pp., 17 pl.
" *L. Vanuxem*, Final Rep., 3d Dist., Albany, 4to, 306 pp.
1843. *J. Hall*, " " 4th " " 4to, 525 pp., 19 pl.
1847. " " " Paleontology, Vol. I, Albany, 4to, 338 pp., 100 pl.
1852. *J. Hall*, Final Rep., Paleontology, Vol. II, Albany, 4to, 362 pp. 104 pl.
1859. *J. Hall*, Final Rep., Paleontology, Vol. III, Albany, 4to, 532 pp., 140 pl.
1846. *E. Emmons*, Final Rep., Agriculture, Albany, 4to, 371 pp., 21 pl., map. (Contains Emmons's "Taconic System.")
1850. *J. Hall*, 3d Reg. Rep., Appendix L, Contrib. to Paleontology, Albany, 8vo, 13 pp., 3 pl.
1857. *J. Hall*, 10th Reg. Rep., Appendix C, Contrib. to Paleontology, Albany, 8vo, 148 pp.
1859. *J. Hall*, 12th Reg. Rep., Appendix — Contrib. to Paleontology, Albany, 8vo, 90 pp.
1860. *J. Hall*, 13th Reg. Rep., Appendix F, Contrib. to Paleontology, Albany, 8vo, 76 pp.
1861. *L. Lincklaen*, 14th Reg. Rep., Appendix B, Guide to Geology N. Y., Albany, 8vo, 68 pp., 19 pl.
1861. *J. Hall*, 14th Reg. Rep., Appendix C, Contrib. to Paleontology, Albany, 8vo, 22 pp.
1862. *J. Hall*, 15th Reg. Rep., Appendix —, Contrib. to Paleontology, Albany, 8vo, 170 pp.
1863. *J. Hall*, 16th Reg. Rep., Appendix D, Contrib. to Paleontology, Albany, 8vo, 210 pp. 11 pl.
1864. *J. Hall*, 17th Reg. Rep., Appendix H, Albany, 8vo, 11 pp.
1866. " 18th " " —, " "

NEW JERSEY.

1836. *Henry D. Rogers*, 1st Rep., Philadelphia, 8vo, 188 pp., map.
1840.* *Henry D. Rogers*, Final Rep. (Descr. Geol. N. J.), Philadelphia, 8vo, 301 pp., map. (Reprinted without map, Trenton, 1865.)
1855. *Wm. Kitchell*, 1st Ann. Rep., New Brunswick, 8vo, 100 pp.
1856. " 2d, " Trenton, 8vo, 248 pp.
1857. " 3d, " " 79 pp.
1857. *Geo. H. Cook*, Rep. on Cape May Co., Trenton, 8vo, 211 pp., map.
1864. " 1st Ann. Rep., Trenton, 8vo, 13 pp.
1865. " 2d " " 24 pp., map, section.

PENNSYLVANIA.

1836. *H. D. Rogers*, 1st Ann. Rep., Harrisburg, 8vo, 22 pp.
1838. " 2d " " " 91 pp.
1839. " 3d " " " 119 pp.
1840. " 4th " " " 252 pp.
1841. " 5th " " " 179 pp.
1842. " 6th " " " 28 pp.

1858. *H. D. Rogers*, Final Rep., Vol. I, Philadelphia, [printed at Edinburgh.] 4to, xxvii and 586 pp., 27 pl., 8 sect.
1858. *H. D. Rogers*, Final Rep., Vol. II, Philadelphia, [printed at Edinburgh.] 4to, xxiv and 1045 pp., 45 pl., 7 sect.
1858. *H. D. Rogers*, Final Rep., Atlas, 2 maps (5 sheets), 2 sections.

DELAWARE.

1839.* *Jas. C. Booth*, 1st and 2nd Ann. Rep., Dover, 8vo, 25 pp.
1841. " Final Rep., Dover, 8vo, 188 pp.

MARYLAND.

1834. *J. T. Ducatel* and *J. H. Alexander*, Rep. on Projected Survey, Annapolis, 8vo, 39 pp., map.
1834. *J. H. Alexander*, Rep. on New Map, Annapolis, 8vo, 12 pp., map.
1835.* " Rep. Annapolis, 8vo, 34 pp.
1837. " Rep. " 8vo, 44 pp.
1834. *J. T. Ducatel*, 1st Ann. Rep., Annapolis, 8vo, 44 pp.
1835.* " 2d Ann. Rep., " 8vo, 60 pp. Map and sections.
1836. *J. T. Ducatel*, 3d Ann. Rep., Annapolis, 8vo, 60 pp. Map and sections.
1837. *J. T. Ducatel*, 4th Ann. Rep., Annapolis, 8vo, 60 pp.
1838. " 5th " " 8vo, 33 pp., 4 pl.
1839.* " 6th " " 8vo, 49 pp.
1840. " 7th " " 8vo, 59 pp. 3 pl.
1860. *Philip T. Tyson*, 1st Bienn. Rep., Annapolis, 8vo, 145 and 20 pp., map.
1862. *P. T. Tyson*, 2d Bienn. Rep., Annapolis, 8vo, 92 pp.

VIRGINIA.

1836. *Wm. B. Rogers*, Rep. Geol. Reconn., Philadelphia, 8vo, 143 pp., section.
1838. *W. B. Rogers*, 1st and 2d Ann. Reps., Philad., 8vo, 87 pp.
1839. " 3d Ann. Rep., ——, 4to, 52 pp.
1840. " 4th " Richmond, 8vo, 161 pp.
1841. " 5th " " " 132 pp.

NORTH CAROLINA.

1824. *Denison Olmsted*, 1st Ann. Rep., "Part I," ——, 12mo, 84 pp.
1852. *E. Emmons*, " " Raleigh, 12mo, 181 pp.
1856. " Rep. on Midland Counties, New York and Raleigh, 8vo, 351 pp., 15 pl.
1858.* *E. Emmons*, Rep. Agric. Eastern Counties, New York and Raleigh, 8vo, 314 pp.

SOUTH CAROLINA.

1826.* *L. Vanuxem*, Rep. published in newspapers, and most of it in Mills' Statistics of S. C.
1843.* *Edmund Ruffin*, Agricultural Rep., with Appendix, Columbia, 8vo, 176 pp.
1844. *M. Tuomey*, 1st Ann. Rep., Columbia, 12mo, 63 pp. (including Suppl. to Ruffin's Rep.)

1848. *M. Tuomey*, Final Rep., Columbia, small 4to, 293 and lvi pp., map.
1857. *Oscar M. Lieber*, 1st Ann. Rep., Columbia, 8vo, 136 pp., 9 pl.
1858. " 2d " " 8vo, 143 " 5 "
1859. " 3d " " 8vo, 223 " 3 "
1860.* " 4th " " 8vo, 194 " 4 "

ALABAMA.

1850. *M. Tuomey*, 1st Biennial Rep., Tuscaloosa, 8vo, xxxii and 176 pp.
1853.* " map. ——.
1858. " 2d Biennial Rep., Montgomery, 8vo, xix and 292 pp., map (edited by J. W. Mallet).

MISSISSIPPI.

1854. *B. L. C. Wailes*, 1st Rep., Jackson, 8vo, 371 pp.
1857. *L. Harper*, Prelim. Rep., Jackson, 8vo, 350 pp., 7 pl., map.
1858.* *Eug. W. Hilgard*, Ann. Rep., Geol. and Agric., Jackson, 12mo, 22 pp.
1860. *E. W. Hilgard*, Rep. Geol. and Agric., Jackson, 8vo, 391 pp., map.

TENNESSEE.

1835. *G. Troost*, 3d Rep., Nashville, 12mo, 32 pp., map.
1837. " 4th " " " 37 pp. "
1840. " 5th " " 8vo, 75 pp. "
1841.* " 6th " " 12mo, 48 pp. "
1844.* " 7th " " 8vo, 45 pp. "
1845.* " 8th " " 12mo, 40 pp. "
1848. " 9th " " " 39 pp., 2 pl.
[Troost's 1st and 2d Reports were not published.]
1856. *Jas. M. Safford*, 1st Biennial Rep., Nashville, 8vo, 164 pp., map.
1857. " 2d " " " 11 pp.

KENTUCKY.

1839. *W. W. Mather*, Rep. of Geol. Reconn. (1838), Frankfort, 8vo, 40 pp.
1856. *David D. Owen*, 1st Rep., Frankfort, 8vo, 416 pp., 7 pl., 2 maps, 7 sections.
1857. *D. D. Owen*, 2d Rep., Frankfort, 8vo, 391 pp., Atlas of 10 pl., and 1 chart.
1857. *D. D. Owen*, 3d Rep., Frankfort, 8vo, 589 pp., Atlas of 10 pl., and 1 chart.
1861. *D. D. Owen*, 4th Rep., Frankfort, 8vo, 616 pp.

OHIO.

1836. *S. P. Hildreth*, Legislative Rep. on Survey, Columbus, 12mo, 18 pp. 2 sections.
1837. *John L. Riddell*, Legislat. Rep. on Survey, Columbus, 8vo, 34 pp.
1838. *W. W. Mather*, 1st Ann. Rep., Columbus, 8vo, 134 pp.
" " 2d " " 8vo, 286 "

INDIANA.

1838. *D. D. Owen*, 1st Rep., Indianapolis, 8vo?, 34 pp.
1839. " 2d " " " 54 "

1855.* *R. T. Brown*, Letter to Agric. Board, Indianapolis, 8vo, 30 pp.
1862. *D. D. Owen* and *Richard Owen*, Rep. Geol. Reconn., Indianapolis, 8vo, xvi and 368 pp., 11 pl.

ILLINOIS.

1853. *J. G. Norwood*, Rep. Prog., Springfield, 8vo, 13 pp.
1857. " " on Coals, Chicago, " 98 "
1866. *A. H. Worthen*, Rep. Geology, Vol. I, Springfield, large 8vo, 504 pp., with map and sections.

MICHIGAN.

1838. *Douglass Houghton*, 1st Rep., Detroit, small 8vo, 37 pp.
1839. " 2d " " " 39 and 123 pp.
1840.* " on Salt Springs, (House Doc. Vol. I, p. 18.)
" " 3d Ann. Rep., Detroit, 8vo, 124 pp.
1841. " 4th " " 184 "
" * " Rep. Progress of Maps, ——
1842.* " 5th Ann. Rep., ——
1861. *A. Winchell*, 1st Biennial Rep., Lansing, 12mo, 339 pp.
1846. *A. B. Gray*, Rep. to War Dept. on Mineral Lands, Lake Superior, Washington, 8vo, 23 pp., map.
1849. *Chas. T. Jackson*, Rep. (U. S.) on Mineral Lands, Washington, 8vo, 237 pp., 6 maps.
1849. *J. W. Foster* and *J. D. Whitney*, Rep. (U. S.) on Mineral Lands, Washington, 8vo, 330 pp., 9 maps, 7 pl.
1849. *Wm. A. Burt*, Rep. (U. S.) Mineral lands L. Superior, Washington, 8vo, 63 pp.
" *Bela Hubbard*, Rep. (U. S.) Mineral lands L. Superior, Washington, 8vo, 76 pp.
1850. *J. W. Foster* and *J. D. Whitney*, Rep. (U. S.) Geol. L. Superior Land Dist., Part I, Washington, 8vo, 224 pp., 4 maps, 12 pl.
1851. *J. W. Foster* and *J. D. Whitney*, Rep. (U. S.) Geol. L. Superior Land Dist., Part II, Washington, 8vo, xvi and 406 pp., 35 pl.

WISCONSIN.

1854. *Edward Daniels*, 1st Ann. Rep., Madison, 12mo, 84 pp.
1855. *J. G. Percival*, " " " 101 " map.
1856. " 2d " " " 111 "
1858. *Edward Daniels*, " " " " 62 "
" " and others, " " " " 12 "
1860.* *J. Hall*, Ann. Rep. (for 1859), Madison, ——
1861. " " Madison, 12mo, 52 pp.
1862. *J. Hall* and *J. D. Whitney*, Final Rep., Vol. I, Albany, 8vo, 455 pp., 10 pl., 2 maps.

[To be concluded.]

9. *Human remains in Belgium.*—Mr. EDWARD DUPONT has presented to the Royal Academy of Brussels (June 30, 1866) a paper on his later researches in the caverns on the borders of the Lesse, near where it empties into the Meuse. He has examined two localities near Walsen, one

of which was not known before, and he has had the good fortune to find there numerous bones which he has described in detail.

It is known that in a work upon the Quaternary deposits of the province of Namur the author of these researches has distinguished three stages, which he designates, respectively, (1) from the presence of the Mammoth (*Elephas primigenius*), (2) of the great Cave Bear (*Ursus spelæus*), and (3) of the Reindeer (*Cervus tarandus*). But up to the present time he had found but few traces of the fauna of the first two stages. The two caverns called the Hyena cave and the Naulette cave have given him numerous remains which have confirmed his first impressions. In the first of these caves, called the cave of the Hyena, because of the quantity of bones of the *Hyœna spelœa* which it contains, he found teeth of the cave bear (*Ursus spelœus*), of the *Elephas primigenius* (a milk tooth), also bones of the *Rhinoceros tichorinus*, horse, fox, reindeer, &c., nearly all bearing marked traces of the teeth of a strong Carnivore. All the extremities are gnawed and there are no traces of the epiphyses; a great number of splinters are also gnawed. The bones of the hyena, on the contrary, bear no such traces, and as this, moreover, is the only Carnivore he has found there, he is inclined to believe that this was a hyena cave, and that the bones of other animals found in the same bed are the remains of their repast. The results of the explorations of this cave Mr. Dupont considers very important in their bearing upon the Quaternary deposits. These excavations determine the exact place, in the series, of the great cave Mammifers. In fact, the debris of the principal animals which compose this fauna are found also in the sandy-argillaceous stratified beds of alluvium (or "lehm") of the country; they evidently existed immediately before the deposit of these beds. Moreover, these stratified beds of gritty clay are found in the caverns as well as in the Quaternary outside in the province of Namur, between the great deposit of rolled pebbles on one side, and the argillaceous pebble deposit on the other. But the deposit of the rolled pebbles in the valleys is eminently characterized by the remains of the *Elephas primigenius*, so that the beds have justly received their name from their presence. On the other hand the deposit of yellow clay containing pebbles, which accords exactly with the deposit called red alluvium in the Paris basin, includes in the caves the fauna of the reindeer properly so called, that remarkable fauna whose distinguishing feature is the absence of all extinct species, and the presence of a series of animals still in existence, but now banished to colder climates. The true cave fauna, characterized principally by the great Carnivores, which are at the present day wholly extinct, separates the two fauna. This accords with the ideas Mr. Dupont had before brought forward in his paper on the Quaternary division of the province of Namur.

In the second of these caverns, named La Naulette, Mr. Dupont has found, among other organic remains, a bone of the *Elephas primigenius*, and a human jaw with a human ulna. The antiquity of these last bones cannot be contested since they are covered by several beds of stalagmites between which Mr. Dupont has recognized his medium stage, and upon which rest the deposits of the reindeer age. On the other hand this jaw differs from those of all the races found in Europe at the present day, in

its forward prolongation (prognathism), a characteristic which is apparent to a certain degree in a jaw bone found by Mr. de Vibraye in the grotto of Arcy, in Bourgogne, associated equally with the *Elephas primigenius* and the *Rhinoceros tichorinus;* this peculiarity has also been observed in nine other jaws collected together in a cavern called the Cave of Frontal, at Furfooz. Mr. Dupont's discovery of these human remains is confirmed by Mr. Dumon, chief engineer of bridges and causeways, Mr. Eugene Cœmans, Mr. John Jones, and Lord Talbot of Malahide, who visited the cavern at the precise moment that the jaw was found, and who were convinced of its association with the other remains. The human bones have also been submitted by him to Messrs. Van Beneden, Spring, Bruner-Bey, Lartet, de Quatrefages, Busk, and Carl Vogt.

Mr. Dupont has found associated with these human remains many bones which bear the trace of the hand of man. One is a fragment of bone which is probably from a Ruminant. This bone is pierced with a hole which is evidently artificial, for the edges show a surprising neatness of finish. Moreover, the edges of this fragment of bone bear marks which appear to have been made with a very sharp instrument. Some persons, among whom is Mr. Quatrefages, believe that it is evidence of some peculiar method of cracking. Many fragments of marrow bones present also indications of man analogous to what has been found in other caverns, the bones evidently having been broken by the hand of man.

Mr. Dupont closes his notice with some remarks upon the fauna concealed in the alluvium of the Hyena and Naulette caves. Although the presence of three animal species may be respectively the distinguishing feature of the three Quaternary stages indicated above, we must conclude from the facts gathered only that these stages correspond to the periods in which the species that they indicate had their principal development, and not that these species did not exist before, or after, the period. Although in this case the beds of rolled pebbles are characterized by the presence of the *Elephas primigenius*, it does not follow that this species occurs only in this deposit, for we find it with the *Elephas meridionalis* in the *Forest beds*, as has been established by Sir C. Lyell in his Antiquity of Man, p. 224, and it was still living in Belgium during the deposit of the stratified alluvial beds (lehm). The *Ursus spelæus* seems to present an analogous fact, since the deposit of rolled pebbles of the cave of Frontal has furnished a canine tooth that appears to belong to this species. The common stag, the brown bear, and chamois are also remarkable examples of the same fact. Finally the reindeer seems to have lived, after the age of the *Elephas meridionalis*, in more southern regions than those in which it is now found; it existed in our regions with the *Elephas primigenius*, *Rhinoceros tichorinus*, &c., but it never acquired there that great numerical development which permits us to regard it as characterizing by its remains a long geological epoch subsequent to the disappearance of these large Quaternary species.

The article continues with results of other observations of interest.—*L'Institut*, Nov. 21st, 1866.

10. *Hübnerite, a new mineral.*—E. Riotte has described, in the Reese River Reveille, a new tungstate of manganese, entirely free from iron,

found in the Erie and Enterprise veins in Monmouth district, Nevada. From a notice of Riotte's paper by H. Credner,* we take the following. Crystallization trimetric, $I : I = 105°$; generally in columnar masses or foliated, imbedded in quartz. Cleavage brachydiagonal, very perfect. Fracture, uneven. H.=4·5. G.=7·9. Color brownish-red to brownish-black. Streak yellowish-brown. Luster adamantine on the cleavage plane, and otherwise greasy. Translucent to opaque. Analysis by Riotte and Hübner gave, WO_3 76·4, MnO 23·4. BB. gives reactions for both tungstic acid and manganese. Partially soluble in chlorhydric acid leaving a yellow residue almost completely soluble in ammonia. Hübnerite is, according to Dr. Adelberg, found in both of the localities in a vein three to four feet wide in a metamorphic clay-slate, and is associated with scheelite, fluor-spar and apatite. A later article† by Breithaupt questions the correctness of the crystallographic measurements, and gives the density as 7·14.

11. *Mineralogical Notices;* by Wm. P. Blake.‡—*Kerargyrite.* Chlorid of silver occurs in thin crusts on gold-bearing quartz in the Morgan gold mine, Carson Hill, Calaveras county. This vein is in the main gold belt, and is regarded as a part of the chief gold vein of the state. It is noted for the massive specimens of vein gold which it affords. The association of chlorid of silver with the gold is novel, and has not been before observed by myself or others to my knowledge. A little galena occurs in the same vein, and in another part of it, gray copper ore, probably argentiferous, occurs sparingly and may be the source of the chlorid of silver. The crusts are about the thickness of an ordinary visiting card, and when freshly cut or scraped have a delicate pearl-gray color, which speedily changes to purple in the sunlight.

This species is also found in remarkably fine specimens in the Poorman lode,§ Idaho, associated with proustite, native silver, and native gold. Sheets of the chlorid are taken out of the soft clay of the vein, and are from one-eighth to one-quarter of an inch in thickness. It is also found in irregular massive aggregations of crystals, in cubes, without any modification, and over an eighth of an inch square. The color of my specimens is brown, passing into violet-blue in some portions.

Proustite.—The "ruby silver" which occurs with the chlorid in the Poorman lode, as above, is often in masses of several ounces, or even pounds, in weight, and it is reported to be occasionally seen in beautiful crystals, but none have yet come under my observation.

Copper-glance, Red oxyd of Copper, Native Copper.—These species are found together in the Red Cap claim, Klamath county, Cal., in serpentine. The metallic copper is seen in points throughout the massive sulphuret, and is sometimes enveloped in red oxyd. Both the copper and the oxyd are most abundant near the surface of the masses of ore, and they are apparently formed by the gradual decomposition of the sulphurets.

* Berg. und Hüttenmännisches Zeitung, xxiv, 370. † Ibid., xxv, 157.

‡ A portion of this paper was read before the California Acad. Nat. Sci., Oct. 15th, 1866, and another portion bears the date of Nov. 17th.

§ Specimens from this well-known locality are contained in many of the collections in the east.—G. J. B.

Danaite.—A cobaltic variety of mispickel is found associated with iron and copper pyrites at Meadow Lake, Nevada Co., Cal. It is in distinct, well formed, brilliant crystals of a tin-white color, and about a quarter of an inch in diameter. They are modified nearly as in fig. 289, Dana's Mineralogy. This mineral gives cobalt reactions before the blowpipe, and appears to contain a large percentage of this metal. The ore is said to contain nickel also, and is being mined for shipment.

Cinnabar in calcite.—Cinnabar of a beautiful vermilion color is found in Idaho abundantly spread through a gangue of massive compact limestone or marble. No quartz or other minerals are visible in the specimens.

Wulfenite.—Molybdate of lead occurs in the argentiferous lead ores of the Empire mine, Inyo Co., Cal. It is in crusts and seams about one-eighth of an inch thick, and is associated with galena, cerusite, malachite, and chrysocolla. The contrast of the brilliant yellow color of this species with the masses of green silicate of copper renders these specimens very beautiful and desirable for cabinets.

Sulphuret of silver.—This mineral is found in ragged masses matted with quartz crystals, and associated with free gold, in the "Silver Sprout" vein, Kearsarge District, Sierra Nevada.

*Tungstate of manganese.**—I have received from Mr. Ewer, fragments of a mineral from Nevada, which appears to be tungstate of manganese. It is in radiating prismatic crystals; color dark olive-green; high specific gravity, and before the blowpipe gives the reactions of tungstic acid and of manganese.

Specular iron.—Mr. Bennett of Durango, Mexico, has sent me some interesting crystallizations of specular iron ore, associated with oxyd of tin, from the tin washings of that place.

Tetrahedrite, galena, cerusite, pyromorphite, blende, with a little *red copper ore* occur together in the Chicago claim, Shasta county, Cal. The ore is rich in silver.

III. BOTANY.

1. *The Miscellaneous Botanical works of* Robert Brown, Esq., D.C.L., F.R.S., Foreign Associate of the Academy of Sciences of the Institute of France. Vol. I, containing 1, *Geographico-Botanical*, and 2, *Structural and Physiological Memoirs.* London: Published for the Ray Society by Robert Hardwicke, 192, Piccadilly. 1866. 8vo.—It was well determined by the Ray Society to collect and reprint Mr. Brown's published papers, originally scattered through various volumes, many of them little accessible. And Mr. Bennett, his intimate associate, and his successor at the British Museum, was the only proper editor. He has added to this volume a full and elaborate index,—a great boon to botanists,—also the following brief Preface:—

"The present volume contains the first portion of the works of the distinguished author, now for the first time collected in England, and reprinted from the originals, without change, in accordance with his express desire. It had been his intention to reprint them himself with annotations; but, unfortunately for science, this intention was never carried out, and it remained for the editor simply to superintend a verbatim reprint.

* This mineral is apparently Hübnerite, noticed on a previous page.—G. J. B.

"The memoirs are arranged in three divisions,—1st, Geographico-Botanical; 2d, Structural and Physiological; 3d, Systematic. Of course this arrangement is in some degree arbitrary, inasmuch as observations relating to both of the other divisions are continually occurring in the memoirs referred to each of them; but on the whole it has appeared to be the most convenient for reference. The present volume contains the first two of these divisions; the second will be devoted to Systematic Memoirs and Miscellaneous Descriptions of Plants; and a separate volume in large 4to, will contain the illustrative figures to both."

The memoirs are arranged according to date. The first volume consequently begins with the "*General Remarks on the Botany of Terra Australis*," in Flinders' Voyage, 1814; and ends with "*Some Account of Triplosporite, an undescribed Fossil Fruit*, 1851. The fruit is now pretty well determined to be that of *Lepidostrobus*. The most important of Mr. Brown's writings are therefore comprised in this volume, and the study of and reference to their rich and varied contents is immensely facilitated by the admirable index prepared, upon which the editor has evidently bestowed great labor and care. A. G.

2. *Nature of Anthers, &c.*—J. Mueller, the elaborator of the *Euphorbiaceæ* for DeCandolle's Prodromus, has published three brief papers in the Mémoires de la Société de Phys. et d'Hist. Nat. de Geneve, upon points relative to the anther which fell under his observation in the progress of his work. The first is a case in which the anther had reverted to a leaf, giving evidence that this organ is homologous with a plane lamina, its margins or line of dehiscence answering to the margins of a leaf. The second is upon the trilocular anther of *Pachystemon*, neatly showing that this (and by just analogy the three-celled anther of *Ayenia* also) is not a combination, but answers to a single leaf. The third exhibits the double flexure in the bud, of the apex of the filament in *Cephalocroton*, the anther remaining upright, as contrasted with the inverted anthers of *Croton*. This reminds us to take some notice of—

3. *An Innovation in Nomenclature in the recently issued volume of the Prodromus.* Take, for example, the genus *Cephalocroton*, established by Hochstetter, in 1841. It appears that Baillon had reduced to it two or three species upon which he had formerly constituted two other genera; and now Dr. Müller gives the genus as "*Cephalocroton* Baillon." Take next the genus *Ricinocarpus*, established by Desfontaines and adopted by the early monographer of the order, Adrien Jussieu. It happens that the *original* of the genus has been published by Sprengel under the name of *Rœperia*, and named also by Sieber *Echinosphæra*. Is it for adding these two names as synonyms that the *Prodromus* writes "*Ricinocarpus* Müll. Arg."? Evidently not, as these synonyms are given by Endlicher. Is it because of two species now first described, of which the author constitutes two new sections of the genus, the rest of the species constituting *Euricinocarpus?* No other reason is apparent. But here no one, not the author himself, ever regarded these two new plants as anything else than species of *Ricinocarpus*, that is to say, of Desfontaines' genus.

Again, Adrien Jussieu dedicated to his friend Ampere a genus of a single known species: Brongniart added a second species: Dr. Müller

has now added a third, and, forming for it a separate section, has taken the genus as his own! These are fair illustrations of the plan pursued throughout the volume. The principle acted on appears to be, that whenever an author revises a genus and extends its limits, or adds any species which are not wholly homogeneous with the old ones, although in his opinion they belong to it, he may supersede the name of the founder of the genus by his own.

We suppose the rule would hold as well in case of the restriction, as of the amplification of a genus. Upon this principle how many genera would be left to Linnæus? Not *Berberis*, for it would be attributed to the botanist who first remanded the pinnate species which composed Nuttall's genus *Mahonia*. Not even *Podophyllum*, for the second species, being hexandrous, brings in an important modification of the generic character. But the volume under consideration itself exemplifies the inevitable result. Out of the seventeen admitted Linnæan or ante-Linnæan genera it comprises, nine have lost the name of the founder. Half of the eight which retain it have only from one to six species each; and most of the rest, viz., *Stillingia*, *Omphalea*, *Manihot*, and *Andrachne*, have escaped apparently through some variation of the rule, or laxity in its enforcement, the grounds of which are not clearly obvious.

The same treatment is, naturally enough, applied to species. Take a single example from those presented on almost every page of the volume. Linnæus reduced all the forms of Castor-oil plant he knew to *Ricinus communis* L. Dr. Müller does the same: but he knows many more forms, and has arranged them with exhaustive particularity under four primary divisions, sixteen varieties, and some of these into almost as many sub-varieties. So this equivalent conclusion, resulting from a survey of more materials, is represented not by *R. communis* L., but by *R. communis* Müll. Arg. Now who shall decide upon the quantity of materials to be revised, or number of synonyms to be reduced, which may entitle a writer to take this great liberty? The only case which might seem to warrant it, is when two or more species of the same author and the same date are comprehended in one under a general character. Instances of the sort are probably to be met with in the work under consideration. But *Mercurialis annua*—from which the name of Linnæus has dropped—is not a case in point, *M. ambigua* (regarded as a mere state of the former) having been published by the younger Linnæus.

Finally, there is a foot-note on p. 192, which should not pass unnoticed. For the statement, "Nomina non rite edita sunt nomina inania omnique prioritate carentia," as interpreted by the use made of it upon the occasion of the note, opens the way by which a just and well-established rule is made to operate in violation of the prevalent comity of botanists. Our own remarks upon this very point, in this Journal for March, 1864, p. 279, have been once or twice reprinted in Europe, without dissent; and we see no good reason as yet for recalling them. While the rule in regard to priority has its proper scope in maintaining that "manuscript names in collections, however public, should assert no claim as against properly published names," still, "the distribution of named specimens [and, *à fortiori*, of these in sets, widely distributed among herbaria, as were Sieber's], where and as far as they go, is held to be tan-

tamount to publication." So of names and original observations attached to specimens in herbaria. These names are always attached antecedently to publication; and a monographer, having, as he should, free access to all herbaria within his reach, might work a deal of harm if he did not regard such names as *to him* all the same as if already published. The full recognition of an obligation to do this has sensibly quickened the advance of botany, by securing the early distribution of materials which might otherwise have been long withheld, and by widely opening herbaria to all competent working botanists, and especially to monographers, who should be the last to deprecate the system. No doubt, like other good and necessary things, it is open to abuse and may now and then work some hardship. We would only remark that, whether on the whole the custom be good or bad, it is one for the introduction and maintenance of which we are indebted to no single botanist so much as to the founder of the Prodromus. And he, of all others, would be most surprised to learn that *Leptocaulis echinatus*, &c., *Trepocarpus Æthusæ*, and *Eulophus Americanus*, were Candollian and not Nuttallian genera and species.

Upon the whole subject we would remark, in brief, that it can hardly be supposed that these innovations will pass unquestioned; that no living botanist now stands in such position that he can becomingly set aside *mero motu* recognized usages in nomenclature; that the closing volumes of the Prodromus, which for forty years has been most efficient in establishing these usages, is hardly the proper place for changing them; and that, finally, a Botanical Congress, such as that over which, last spring, the distinguished editor of the Prodromus so happily presided, would have been a proper body to consult upon subjects of such delicacy and general interest. A. G.

4. *Mémoire sur la Famille des Pipéracées*, par M. Casimir DeCandolle. 4to pamph., pp. 32, and with 7 plates. (Extr. from *Mém. Soc. Phys. and d'Hist. Nat. Genève*, XVIII, 1866.)—The younger DeCandolle, having elaborated for the Prodromus the order *Piperaceæ*, has consigned the more interesting results of his study of the anatomy and general structure of these peculiar plants to the present article, in which, also, he indicates the grounds upon which he has reduced all the proposed piperaceous genera to three. The structural and histological details are full of interest, especially what relates to the wood of the stem; but we must defer an abstract, perhaps until that portion of the Prodromus is issued. A. G.

5. *American Heather.*—The question, whether *Calluna* is or is not indigenous to the New World,—which during several years past has been repeatedly referred to in this Journal, as additional facts came to our notice,—has now taken a new turn, Dr. Seemann, in his Journal of Botany for October last, having published and neatly figured "the Newfoundland Heather" as a distinct species, *Calluna Atlantica*. He founds it upon specimens originally from Newfoundland, which have been for some years cultivated by Dr. Moore in the Glasnevin Gardens, Dublin, side by side with the common European Heather. The diagnosis attempted, Dr. Seemann admits to be as yet far from satisfactory, except as to a biological distinction observed by Dr. Moore, viz., "that whilst the Newfoundland one always suffered from frost, and turned brown during the

mild Irish winter, the common British form, growing by its side, was unaffected by cold and retained its usual green color." Although "no argument can possibly set aside" this fact, yet its value as a character has to be considered. Probably in the station from which these specimens were lately transferred, as well as in Iceland and the higher Alps, whence Dr. Seemann has the same form, the plant was accustomed to complete protection by snow from changes of temperature the whole winter through. Unfortunately we have no specimens from Newfoundland, and Dr. Seemann does not speak of the Cape Breton, Nova Scotian or New England plants. Upon examination of these, we do not find that the indicated differences in structure (mainly the naked pedicels, broader sepals, and tip of flowering branches not continued into a leafy shoot while the flowering lasts) coincide or hold out. So that as yet a second species can hardly be said to be established. A. G.

IV. ASTRONOMY.

1. *Observations of Venus near its inferior Conjunction.*—With the excellent Equatorial of the Sheffield Scientific School, made by Clark & Sons, and having 9 inches clear aperture, Venus was carefully observed, in close proximity to the Sun, both before and after her late inferior conjunction, which happened on the 11th of December. At her nearest approach ($9^h\ 52^m$ A.M.), the planet was only 22′ from the Sun's northern limb, and had the conjunction occurred a day earlier, there would have been a transit.

On the 10th, the planet was seen and measured, at $3^h\ 30^m$ P.M., when only 1° 8′ from the Sun's limb, and might have been observed later, but for the risk to the eyes, (already severely tried,) from the strong sunlight, which could not well be shut off from the telescope.

On the day of conjunction, no attempt was made to find the planet. On the day following, (the 12th,) it was again seen, at $11^h\ 30^m$ A. M., being then about 1° 36′ from the Sun's limb.

Some days before the conjunction, it was apparent that the crescent formed more than a semicircle—on the 7th, full 40° more by measurement. On the 10th, it formed a *complete circle*—bright, thin and delicate (the crescent proper), on the side toward the Sun, but on the opposite side, a mere faint line of light, very difficult to be seen, on account of the strong light in the field, and the atmospheric disturbance. Yet, by glimpses, it was distinctly perceived as a ring, by several observers, and constantly as more than three-fourths of a circle.

The appearances were similar, though perhaps a little better seen, on the 12th, the day after the conjunction. Yet, the planet was then only half a degree farther from the Sun, and the full ring could be made out only in the more favorable moments with respect to light and atmosphere—particularly, when the light, both of the sun and of the planet, was partially cut off from the object glass, by the shutter of the observatory. Such a compromise between sun-light and planet-light gave generally the best views, except twice, about noon, when, fortunately, a passing cloud left the planet in sight for a few seconds, while yet the Sun was obscured. The background was then comparatively dark, and the

thread of light around the limb opposite to the sun perfectly distinct and complete. The northern portion of the crescent proper, however, did not diminish uniformly in brightness, or apparent thickness, toward the cusp, but a considerable space, between 25 and 50 degrees from the vertex to the left, by estimate, was very perceptibly fainter than a like portion of the circumference next beyond toward the right, whence it gradually narrowed to the mere faint line of light before mentioned. These observations were made between half past 11 and half past 1 o'clock.

At $2^h\ 15^m$ P. M., the planet was readily found with a portable 5 foot Clark telescope of $4\frac{2}{3}$ inches aperture, by taking a position in the shadow of a chimney some 50 or 60 feet distant. The complete ring, and the faint portion of the crescent proper, just described, were both distinctly seen—better, in fact, than with the equatorial, except in the cases mentioned, when the sun was intercepted by a passing cloud.

Observations were prevented on the 13th. On the 14th, at noon, the visible cusps extended full 50° beyond a semicircle, but no irregularity in brightness was noticed, as on the 12th. On the 15th, the cusps had receded to 30°, and on the 18th, to 22°, beyond a semicircle.

These observations have a direct and obvious bearing upon the question of the atmosphere of Venus.

The powers used were from 80 to 200 on the Equatorial, and 90 on the smaller telescope.

For the measurements, a position-micrometer by Dollond was employed. C. S. L.

Sheffield Scientific School, Dec. 29, 1866.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Telegraphic Determination of Longitude between Europe and America.*—Our readers will be gratified to learn that the undertaking of measuring the longitude between the Observatory at Greenwich England, at the stations of the geodetic survey of the United States, by means of the Atlantic cable and the connecting Telegraph lines, has been successfully accomplished, under the auspices of the United States coast survey. We are informed that the preliminary computations, such as could be made during the progress of the work exhibit an unexpectedly close agreement of results. The signals transmitted by the cable possess far greater sharpness than was anticipated, and the time of transmission has been found remarkably constant. By the liberality of the Anglo-American Telegraph Company the use of both cables was freely tendered for the transmission of signals and experiments on transmission Time. The Astronomer Royal gave his co-operation in connecting the European terminus of the cable with Greenwich, and every facility was afforded by the officers of the American and Provincial telegraph lines, in a truly liberal spirit. An interesting account of the operations may be looked for at the January meeting of the National Academy of Sciences, by Dr. B. A. Gould, under whose direction the work has been executed and who occupied the terminus in Ireland. J. E. H.

2. *Mr. George Peabody's recent gifts to Science.*—The last number of this Journal contained an announcement of Mr. Peabody's gift of $150,000 to Harvard College, for the establishment of a museum of American Archæology, and Ethnology, and the same amount to Yale College for a museum of Natural History. His donations to these institutions were accompanied by the following statements of his wishes in regard to the disposition of the fund.

GIFT TO HARVARD COLLEGE.

Georgetown, October 8, 1866.

To the Hon. ROBERT C. WINTHROP, His Excellency CHARLES FRANCIS ADAMS, FRANCIS PEABODY, STEPHEN SALISBURY, ASA GRAY, JEFFRIES WYMAN, and GEORGE PEABODY RUSSELL, Esqrs.

Gentlemen,—Accompanying this letter I enclose an instrument giving to you one hundred and fifty thousand dollars ($150,000) in trust for the foundation and maintenance of a Museum and Professorship of American Archæology and Ethnology in connection with Harvard University.

I have for some years had the purpose of contributing, as I might find opportunity, to extend the usefulness of the honored and ancient university of our Commonwealth, and I trust that in view of the importance and national character of the proposed department and its interesting relations to kindred investigations in other countries, the means I have chosen may prove acceptable.

On learning of your acceptance of the trust, and of the assent of the President and Fellows of Harvard College to its terms, I shall be prepared to pay over to you the sum I have named.

Aside from the provisions of the instrument of gift, I leave in your hands the details and management of the trust; only suggesting, that in view of the gradual obliteration or destruction of the works and remains of the ancient races of this continent, the labor of exploration and collection be commenced at as early a day as practicable; and also that in the event of the discovery in America of human remains or implements of an earlier geological period than the present, especial attention be given to their study and their comparison with those found in other countries.

With the hope that the Museum, as thus established and maintained, may be instrumental in promoting and extending its department of science, and with fullest confidence that under your care the best means will be adopted to secure the end desired,

I am, with great respect, your humble servant,

GEORGE PEABODY.

I do hereby give to Robert C. Winthrop of Boston, Charles Francis Adams of Quincy, Francis Peabody of Salem, Stephen Salisbury of Worcester, Asa Gray of Cambridge, Jeffries Wyman of Cambridge, and George Peabody Russell of Salem, all of Massachusetts, the sum of one hundred and fifty thousand dollars, to be by them, and their successors, held in trust to found and maintain a Museum of American Archæology and Ethnology, in connection with Harvard University, in the city of Cambridge, and Commonwealth of Massachusetts.

Of this sum I direct that my said trustees shall invest forty-five thousand dollars as a fund, the income of which shall be applied to forming and preserving collections of antiquities, and objects relating to the early races of the American Continent, or such (including such books and works as may form a good working library for the departments of science indicated) as shall be requisite for the investigation and illustration of Archæology and Ethnology in general, in main and special reference, however, to the Aboriginal American races.

I direct that the income of the further sum of forty-five thousand dollars shall be applied by my said trustees to the establishment and maintenance of a Professorship of American Archæology and Ethnology in Harvard University; said professor shall be appointed by the President and Fellows of Harvard College, with the concurrence of the overseers, in the same manner as other professors are appointed, but upon the nomination of the founder or the board of trustees. He shall have charge of the above-mentioned collections, and shall deliver one or more courses of lectures annually, under the direction of the government of the university, on subjects connected with said departments of science.

Until this professorship is filled, or during the time it may be vacant, the income from the fund appropriated to it shall be devoted to the care and increase of the collections.

I further direct that the remaining sum of sixty thousand dollars be invested and accumulated as a Building Fund, until it shall amount to at least one hundred thousand dollars, when it may be employed in the erection of a suitable fire-proof museum building, upon land to be given for that purpose, free of cost or rental, by the president and fellows of Harvard College, the building when completed, to become the property of the college, for the uses of this trust, and none other.

The board of trustees I have thus constituted shall always be composed of seven persons, and it is my wish that the office of chairman be filled by Mr. Winthrop,—in the event of his death or resignation, by Mr. Adams, and so successively in the order I have named above. The trustees shall keep a record of their doings and shall annually prepare a report setting forth the condition of the trust and funds, and the amount of income received and paid out by them, during the previous year. This report, signed by the trustees, shall be presented to the president and fellows of the college.

In the event of the death or resignation of Mr. Winthrop, I direct that the vacancy in the number of the board be filled by the president of the Massachusetts Historical Society, who *ex officio* shall forever after be a member of the board. In the event of the death or resignation of Mr. Peabody, the vacancy to be filled by the president of the scientific body now established in the city of Salem, under the name of the Essex Institute; of Mr. Salisbury, by the president of the American Antiquarian Society; of Prof. Gray, by the president of the American Academy of Arts and Sciences; and of Prof. Wyman, by the president of the Boston Society of Natural History, all of whom shall forever after be *ex officio* members of the board.

Should the president of either of the societies I have named decline to act as a trustee, such vacancy, and all other vacancies that may occur

in the number of the trustees, shall be filled by the remaining trustees, who shall, within a reasonable time, make the appointment or appointments.

I give to my said trustees the liberty to obtain from the Legislature an act of incorporation if they deem it desirable, to make all necessary by-laws, to appoint a treasurer, and to enter into any arrangements and agreements with the government of Harvard College, not inconsistent with the terms of this trust, which may, in their opinion, be expedient.

(Signed) GEORGE PEABODY.

Georgetown, Oct. 8, 1866.

GIFT TO YALE COLLEGE.

New York, Oct. 22, 1866.

To Professor JAMES D. DANA, Hon. JAMES DIXON, Hon. ROBERT C. WINTHROP, Professor BENJAMIN SILLIMAN, Professor GEORGE J. BRUSH, Professor OTHNIEL C. MARSH, and GEORGE PEABODY WETMORE, Esq.

Gentlemen,—With this letter I enclose an instrument giving to you one hundred and fifty thousand dollars ($150,000) in trust for the foundation and maintenance of a Museum of Natural History, especially of the departments Zoology, Geology and Mineralogy, in connection with Yale College.

I some years ago expressed my intention of making a donation to this distinguished institution, and convinced as I am of the importance of the natural sciences, and of the increasing interest taken in their study, it now affords me great pleasure to aid in advancing these departments of knowledge.

The rapid advance which natural science is now making renders it necessary to provide for the future wants of such a museum, as well as its present requirements, and I trust that the portion of the fund designed for this purpose will be found sufficient.

On learning of your acceptance of this trust, and of the assent of the President and Fellows of Yale College to its conditions, I shall be prepared to pay over to you the sum I have named, and I may then have some additional suggestions to make in regard to the general management of the trust.

Confident that under your direction this trust will be faithfully and successfully administered,

I am, with great respect, your obedient servant,

GEORGE PEABODY.

I hereby give to James Dwight Dana, of New Haven, Conn.; James Dixon, of Hartford, Conn.; Robert C. Winthrop, of Boston, Mass.; Benjamin Silliman, of New Haven, Conn.; George Jarvis Brush, of New Haven, Conn.; Othniel Charles Marsh, of New Haven, Conn.; and George Peabody Wetmore, of Newport, R. I., on his attaining his majority, the sum of one hundred and fifty thousand dollars, to be by them or their successors held in trust to found and maintain a *Museum of Natural History*, especially of the departments of Zoology, Geology and Mineralogy, in connection with Yale College, in the City of New Haven, State of Connecticut.

Of this sum I direct that my said trustees devote a part, not to exceed one hundred thousand dollars, to the erection, upon land to be given for that purpose, free of cost or rental, by the President and Fellows of Yale College, in New Haven, of a fire-proof museum building, adapted to the present requirements of these three departments of science, but planned with especial reference to its subsequent enlargement, the building, when completed, to become the property of said college for the uses of this trust, and none other.

I further direct that the sum of twenty thousand dollars be invested, and accumulate as a building fund until it shall amount to at least one hundred thousand dollars, when it may be employed by my said trustees, or their successors, in the erection of one or more additions to the museum building, or in its final completion; the land for the same also to be provided free of cost or rental by the President and Fellows of Yale College, in New Haven, and the entire structure when completed to be the property of Yale College, for the uses of this trust and none other.

I further direct that thirty thousand dollars, the remaining portion of this donation, be invested, and the income from it be expended by my said trustees, or their successors, for the care of the museum, increase of its collections and general interests of the departments of science already named; the part of the income remaining after providing for the general care of the museum to be apportioned in the following manner; three-sevenths to zoology, three-sevenths to geology, and one-seventh to mineralogy; the said collections, as well as the museum building, to be exclusively for the benefit of the various departments of said College.

The Board of Trustees I have thus constituted shall always be composed of seven persons, of whom not more than four shall at any one time be members of the Faculty of Yale College. They shall have the general management of the museum, keep a record of their doings, and annually prepare a report setting forth the condition of the trust and funds, and the amount of income received and paid out by them during the previous year. This report, signed by the trustees, shall be presented to the President and Fellows of Yale College, in New Haven, at their annual summer session, and be by them filed in the archives of said college.

In the event of the death or resignation of either of my said trustees, I direct that his successor be the Governor of Connecticut, who, *ex officio*, shall forever after be a member of the Board. Any other vacancy that may occur in the Board of Trustees, either by resignation or by death, shall be filled by the remaining trustees within a reasonable time after such vacancy shall have occurred.

I give to my said trustees, and their successors, the liberty to appoint a treasurer, and to enter into any agreements with the President and Fellows of Yale College, not inconsistent with the terms of this trust, which may in their opinion be expedient.

(Signed,) GEORGE PEABODY.

New York, Oct. 22, 1866.

In addition to the above donations Mr. Peabody has recently given $500,000 to the Peabody Institute established by him at Baltimore, making its present endowment $1,000,000; and has increased to $250,000

his previous gift to the Peabody Institute in his native town of Danvers, Mass. Each of these institutions will contain an extensive library, and annually provide several courses of free lectures on scientific and literary subjects. Mr. Peabody has, moreover, just made a donation of $25,000 to Phillips Academy, Andover, Mass., to provide instruction in the natural sciences and mathematics, and another of the same amount to Kenyon College, Ohio, for a similar purpose. He has also recently given $20,000 to the library fund of the Maryland Historical Society, and founded free libraries at Georgetown, Mass., and Thetford, Vt.

These munificent gifts, amounting in all to nearly $1,650,000, place the donor, already so highly honored for his other noble charities, among the foremost benefactors of science, and cannot fail to exert a most beneficial influence upon the educational interests of this country.

OBITUARY.

GEORGE W. FEATHERSTONHAUGH, the author of a geological report on the Missouri and Red rivers, published by our government, in 1834, and originator and editor of Featherstonhaugh's Geological Journal published in 1831, 1832 at Philadelphia, died at Havre on Sept. 28, in his eightieth year. He had been consul at Havre for nearly twenty years.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *Geological Map of the Department of the Seine*, by Mr. DELESSE. —This elaborate and beautiful Chart, the publication of which was announced in the last number of this Journal (p. 440), is worthy of a careful examination by all who are interested in the construction of maps of this kind, or in the geology of the region it embraces. It is constructed on a scale of 1 : 25000, and the method employed by Delesse is essentially the same as that used in his map of the city of Paris. The various formations, with exception of the diluvium, which is supposed to be removed, are represented by colors as in ordinary geological maps. In addition to this a new feature is introduced, which will doubtless be often employed in the future, and hence deserves more than a passing notice. By means of a system of horizontal curves, drawn at a perpendicular distances of 20 meters from each other, measured from the level of the sea, a subterranean geological map, or rather a series of maps, is formed on which the surfaces of the principal formations for each level is indicated. To obtain these curves Mr. Delesse examined all the various localities, where it was possible to make a geological section,—especially the quarries, wells, and other surface excavations, as well as the numerous subterranean works, executed within the last few years in the environs of Paris. Starting from data thus obtained, the elevation of the points, where a geological section was made, was accurately determined by leveling, and the operation repeated until a system of points was obtained sufficiently near together to admit of the tracing of horizontal curves indicating each surface. In this manner is represented the upper surface of the Cretaceous, the Plastic Clay, the White marls above the Calcaire grossier, the Travertin of St. Ouen, the Green clays, the Sandstone of Fontainebleau, and finally the under surface of the Diluvium. The intervening formations are, of course, also indicated by the same curves.

By the aid of this subterranean geological map, it is easy to determine the strata which would be struck at any given point in the vicinity of Paris; for the colors indicate the formation lying immediately under the diluvium, and, as the point selected will fall between two horizontal curves representing the surfaces of the different strata, a fourth proportional is all that is required to calculate the depth at which any one of these surfaces may be reached.

The method employed in the execution of the map facilitates, moreover, a thorough study of the formations represented, and may be advantageously used in exploring for deposits of economic value. The chart has other features of interest which will repay examination. It is probably the most elaborate geological map ever constructed, and will doubtless long be regarded as a model. O. C. M.

2. *The American Naturalist, a Popular Magazine of Natural History.*—Under this title, the Officers of the Essex Institute, Salem, Mass., propose to publish a monthly magazine, commencing early in the present year.

The object of this journal is to supply a long-existing demand for a popular illustrated magazine of Natural History, devoted to the exposition of scientific topics in a free and familiar manner, without those technicalities which often render the mass of such reading tedious and difficult.

Among the contents of the magazine, will be papers on topics of a general and special nature relating to Natural History, illustrated with appropriate wood engravings, and occasional lithographic plates; these papers will be mainly original, but compilations and translations of papers from other sources will be introduced when deemed of sufficient interest. It will also contain accounts of excursions and expeditions made for scientific purposes, with descriptions of the various objects of interest discovered—explanations of the principles of the structure, development and classification of Animals and Plants, both living and fossil, and notices of recent discoveries in Geology and Archæology—directions for collecting, preparing and arranging collections, including descriptions of the latest methods of mounting and preparing specimens—short reviews of scientific and popular works on Natural History—brief notices of the meetings of the Natural History Societies throughout the country—descriptions of scientific museums, and answers to correspondents on scientific topics.

Each number will contain 48 octavo pages of reading matter, besides advertising sheets.

Such a magazine is greatly needed in this country and will doubtless meet the patronage to which its able corps of editors and imposing list of contributors entitle it.

The editors are A. S. Packard, Jr., M.D., in connection with E. S. Morse, Alpheus Hyatt and F. W. Putnam. V.

3. *A Manual of Blowpipe Analysis and Determinative Mineralogy;* by William Elderhorst, M.D. Third edition, 12mo, pp. 179, revised and greatly enlarged. Philadelphia, 1866. (T. Ellwood Zell.)—The value of this useful manual on blowpipe analysis has already been recognized in this Journal in noticing the second edition. But we have failed to discover evidence of the revision and enlargement announced on the title page of the third edition.

4. *Catalogue of the Silurian Fossils of Anticosti, with descriptions of new genera and species;* by E. BILLINGS, F.G.S. 94 pp., large 8vo. Montreal, 1866. From the Geological Survey of Canada, Sir W. E. Logan, Director.—This report on the fossils of Anticosti, by the accomplished paleontologist of the geological survey of Canada, is more than a mere catalogue, as it contains descriptions of many species, with a number of wood-cuts. We defer a further notice to another number.

5. *Lessons in Elementary Chemistry;* by HENRY E. ROSCOE, B.A., F.R.S., Professor of Chemistry in Owens College, Manchester. London, Macmillan & Co., 1866. 18mo, pp. viii, 398.—This book of Dr. Roscoe's, though designedly an elementary work, is written from an advanced standpoint, and, while simple and clear in its statements, it carries the student fully up to the position which the science of chemistry has now reached. Adopting the unitary system in its completeness, it spends but little time in prefatory explanations, but leaves the philosophy to be gathered from the several substances considered. We notice several chapters of great value: especially those on the physical properties of gases; on the atomicity of the elements; on crystallography; on spectrum analysis, and solar and stellar chemistry; and his chapters introductory to organic chemistry. Questions upon the sections, with exercises are given in an appendix. We are glad to see he has abolished the unsatisfactory term "anhydride" and substituted "oxide" instead: the nitr-oxygen series being "nitrous oxide, nitric oxide, nitric trioxide, nitric tetroxide, and nitric pentoxide." His "potassium oxide" seems to us less smooth than the "potassic oxide" of Williamson; and "hydric-potassium sulphate" is improved if written hydro-potassic sulphate. We commend this little volume as one of the best elementary treatises on chemistry in the English language. G. F. B.

6. *Lecture notes for Chemical Students: embracing Mineral and Organic Chemistry;* by EDWARD FRANKLAND, F.R.S., For. Sec. C. S., Professor of Chemistry in the Royal Institution of Great Britain, etc. London, John Van Voorst, Paternoster Row, 1866. 12mo, pp. xx, 422.—Dr. Frankland's views upon the constitution of chemical compounds are well known through his published papers. "Organic as well as inorganic compounds are most instructively represented upon the typical compounds of the most polyatomic radical they contain." Thus upon the types $SbCl_3$* and $SbCl_5$ all the compounds of antimony may be written: as $SbEt_3$ and $SbEt_4I$. And CEtI, allylic iodid, and CMe_2H_2, propylic hydrid, are formed upon the carbon types CO and CO_2. Here it is evident that the composition of these compounds is determined by the equivalence of the highest poly-equivalent radical they contain. Each of the determinants† in the above examples, however, has two equivalencies; antimony acts as a triad and a pentad, carbon as a dyad and a tetrad. Dr. Frankland considers that in the highest compound of any radical its power of combination is saturated; this he calls the point

* H=1, O=16, C=12, Sn=118, Pt=197·4, Me=(CH_3), Et=(C_2H_5), Ho=(HO), etc.

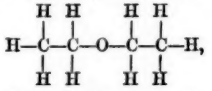
† Dr. Wolcott Gibbs proposes the term "determinant" for the highest poly-equivalent radical in a compound, "object" for the body saturating it, and "resultant" for the product. In ammonia, for example, N is the determinant, H the object, and NH_3 the resultant.

of atomic saturation. In this stage bodies can neither combine with other bodies nor replace them; and they cannot take part in any chemical change without undergoing decomposition. Below this point, however, there are in most cases certain points of comparative stability, at one of which this stability may be at its maximum, the compound undergoing decomposition less readily than when atomically saturated. Thus nitrogen atomically saturated is a pentad; but it has a trivalent and a univalent stage, of which the former is the stage of maximum stability. In this stage bodies may unite directly with or replace other bodies, thus acting like compound radicals. This fact Dr. Frankland explains by supposing that the units of attraction or *bonds* of an atom may saturate each other by pairs. Nitrogen as a pentad is $=\overset{|}{\underset{|}{N}}=$, as a triad $=\overset{|}{N}>$, and a monad $<\overset{|}{N}>$. The maximum number of bonds he calls the "absolute atomicity," the number of bonds united to each other "latent atomicity;" and those free to unite "active atomicity." The absolute atomicity equals of course the sum of the other two. The hexad iron forms ferrous chlorid $^{iv}\dot{F}e''Cl_2$, in which the active atomicity is two; ferric chlorid $'''Fe_2'''Cl_6$, in which it is three; and ferric acid $Fe^{vi}O_2Ho_2$, in which all the atomicity is active.

The book above mentioned is a synopsis of a course of lectures delivered at the Royal College of Chemistry in the fall of 1865–6, and is devoted to a development of these views. In all the rational formulæ it contains, the determinant is written first, printed in heavy type, thus: $\mathbf{O}H_2$, $\mathbf{Sn}O_2$, $\mathbf{Pt}Cl_4$, $\mathbf{C}OKo_2$; indicating that "it is united with all the active bonds of the other radicals, following upon the same line." With one atom of the determinant as above, formulæ are mon-adelphic; with two of equal power di-adelphic, etc. In the latter case one symbol is written below the other, connected by a bracket, thus: $\left\{\begin{matrix}\mathbf{C}H_3\\ \mathbf{C}H_3\end{matrix}\right.$. Dr. Frankland uses the bracket solely to signify that the atoms it connects exchange one bond. These atoms may be united indirectly as in methylic ether, $\left\{\begin{matrix}\mathbf{C}H_3\\ O\\ \mathbf{C}H_3\end{matrix}\right.$, where the dyad oxygen atom links them together. Speaking of rational formulæ the author says, "the formula ought to show, first, whether the hydrogen is combined with the carbon or with the oxygen; or if combined with both, it should indicate how many atoms are united with the carbon and how many with the oxygen. Secondly, the formula ought to show whether the oxygen be united with the carbon or with the hydrogen, or partly with the one and partly with the other; or, lastly, whether it be performing the function of linking hydrogen to carbon." p. 201. The representation in a formula of the mode in which the atoms are held together (and not of course their relative position in space) so necessary to explain cases of isomerism, and which cannot be given by the ordinary typical formulæ, is well obtained by those of Dr. Frankland. In aluminic oxyd, for example, $\left\{\begin{matrix}\mathbf{Al}O\\ \mathbf{Al}O\end{matrix}\right.O$, each aluminum atom exchanges one bond with its fellow, two with the dyad

oxygen atom on the same line, and one with the single oxygen atom intermediate; in ethylic ether, $\left\{\begin{matrix}\mathbf{O}MeH_2\\O\\\mathbf{O}MeH_2\end{matrix}\right.$, the carbon atoms are linked by the oxygen atom, while the other three bonds of each are united respectively with one atom of Me and two of H. To farther elucidate this important fact of combination, Dr. F. makes use of the graphic notation of Crum Brown (using in lectures the glyptic formulæ of Hofmann).*

Aluminic oxyd is $O{=}Al{-}\overset{\diagup O\diagdown}{Al}{=}O$; and ethylic ether is



in which the mode of union of the atoms is the same as that above given. These graphic methods, used more or less by Kekulé, Wurtz, Roscoe, Foster, etc., are most happy in the clearness with which they express the manner in which the bonds of an atom are saturated. Thus Dr. F. represents a molecule of oxygen as $O{=}O$, and one of ozone as $O\overset{\diagup O\diagdown}{-}O$. The formulæ of complex minerals given opposite pages 103 and 177, cannot fail to be of the highest value in mineralogy, if only we know enough of their constitution to say that these are their true rational formulæ.

Dr. Frankland has been remarkably successful in developing these views, and in applying them alike to mineral and organic chemistry. We notice, however, the objectionable term "anhydride" retained; while to our view the term "carbonic dioxide" of Foster (or "carbonylic oxide" $CO\left\langle O\right.$) is far preferable. Again, we think his reason for excluding carbonic acid from the organic acids hardly sufficient. The volume deserves careful study. The novelty of many of its views, coming from so distinguished a chemist, are most suggestive, and cannot fail to exert an important influence upon theoretical chemistry. All the more important elements and compounds, with their modes of preparation, the reaction in each case, their physical and chemical properties, and their modes of decomposition, are most clearly described. And thus the object of the work, to furnish names, formulæ and reactions, and so to save to the student the time spent in copying these in the lecture room is most successfully accomplished.† G. F. B.

7. *Chemical Tables;* by Stephen P. Sharples, S.B. Cambridge, Sever & Francis, 1866. pp. 192.—We cannot give a better idea of the value of this book than by stating the heads under which the tables are arranged. Tables for the calculation of analyses; relating to specific gravity; relating to heat; for gas analysis; relating to light; miscellaneous tables. A table of logarithms closes the volume. A collection of physico-chemical constants like this cannot fail to be of great use both to the physicist and chemist. We need no higher endorsement of the work than that of Dr. Wolcott Gibbs, under whose supervision it was prepared.

* Not. Roy. Inst. of Great Britain, April 7, 1865.

† Quart. Jour. Chem. Soc., xiii, 177, and [2], iv, 372.

8. *A new Chemical Nomenclature;* by S. D. TILLMAN, A.M., Professor of Technology in the Am. Inst. of the city of New York. pp. 23.—This paper was read before the American Association at the Buffalo meeting last August. Prof. T. attempts to embrace both nomenclature and notation in one mnemonical method, which is certainly very ingenious, and surprisingly successful. He exhibits an accurate acquaintance with chemical facts and relations. But his system does away with the old landmarks too entirely to be received into the philosophy of chemistry.

9. *Memoirs of the National Academy*, Vol I. pp. 344, 4to. Washington, 1866.—This first volume of the Memoirs of the National Academy of Sciences contains the following papers read before the Academy in 1864, 1865:

(1.) Reduction of the observations of the fixed stars made by Joseph Le Paute d'Agelet, at Paris, during the years 1783–1785, with a catalogue of the corresponding mean places referred to the equinox of 1800·0; by B. A. GOULD. (2.) On the Saturnian system; by BENJAMIN PEIRCE. (3.) On shooting stars; by H. A. NEWTON. (4.) On the distribution of certain important diseases in the United States; by AUGUSTUS A. GOULD. (5.) On rifled guns; by W. H. C. BARTLETT.

Dr. Gould's paper was noticed in this Journal in our last volume, and the principal part of Prof. Newton's appeared in vol. xxxix.

First Annual Report of the Geology of Kansas; by Prof. B. MUDGE, A.M. 56 pp., 8vo. Lawrence (Kansas), 1866. Report for the year 1864.

Preliminary Report of the Geological Survey of Kansas; by Prof. G. C. SWALLOW, State Geologist. 198 pp., 8vo. Lawrence, 1866. Report for the year 1866.

PROCEEDINGS BOST. NAT. HIST. SOC., Vol. X.—P. 358, Formation of the excavated lake basins of New England; *N. S. Shaler.*—Vol. XI. P. 1, Anatomy and physiology of the ciliary muscle in man; *B. J. Jeffries.*—p. 3, On a cat with supernumerary digits; *B. G. Wilder.*—p. 8, Formation of mountain chains; *N. S. Shaler.*

PROCEEDINGS ACAD. NAT. SCI. PHILADELPHIA, No. 3, June, July and August, 1866. —p. 236, Introduction of American shad into the Alabama river; *W. C. Daniell.*—p. 238, Description of some new species of Diurnal Lepidoptera; *Tryon Reakirt.*—p. 251, Contributions to the paleontology of Illinois and other western states; *F. B. Meek & A. H. Worthen.*—p. 275, Remarks on the remains of a gigantic Dinosaur from Cretaceous green sand of New Jersey; *E. D. Cope.*—p. 279, Notes on the Vespertilionidæ of tropical America; *H. Allan.*

PROCEEDINGS AMER. PHILOSOPH. SOC. PHILADELPHIA, Vol. X, No. 75.—P. 196, Observations on skylight polarization; *P. E. Chase.*—p. 199, Practical application of diamagnetism; *J. C. Cresson.*—p. 201, Native Siamese photography; *Dubois.*—p. 203, Odjibowé François dictionary; *G. A. Belconot.*—p. 206, The auroral display Feb. 20-21; *J. C. Cresson.*—p. 210, On Sullivant & Lesquereux's Musci Bor. Amer.; *T. P. James.*—p. 211, Obituary of Oswald Thompson; *E. K. Price.*—p. 223, On the comparative visibility of Arago's, Babinet's and Brewster's neutral points; *P. E. Chase.*—p. 227, Records of oil-borings (with map); *J. P. Lesley.*—p. 243, On some specimens of Indian pottery (with plate); *F. Peale.*—p. 246, Observations on some species of Spirifera; *J. Hall.*

PROCEEDINGS AMER. ACAD. ARTS AND SCI., Vol. VII.—P. 2, On certain formulæ of interpolation; *Ferrell.*—p. 31, An annual variation in the daily mean level of the ocean and its causes; *Ferrell.*—p. 37, Right ascensions observed at Harvard Coll. Observatory in the years 1862-1865; *T. H. Safford.*—p. 39, Some focal properties of quadratics; *J. E. Oliver.*—p. 52, On the Nephila plumipes, or silk-spider; *B. G. Wilder.*—p. 57, The aqueous lines of the solar spectrum; *J. P. Cooke, Jr.*—p. 68, Notes on the cells of the Bee; *J. Wyman.*—p. 84, New process of organic elementary analysis for substances containing chlorine; *C. M. Warren.*